APRIL, 1915 BULLETIN 358

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Plant Pathology

SOME IMPORTANT LEAF DISEASES OF NURSERY STOCK

By VERN B. STEWART

IMPERIAL BUREAU OF MYCOLOGY
19 FEB. 1923

ITHACA, NEW YORK
PUBLISHED BY THE UNIVERSITY

CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION

Experimenting Staff

BEVERLY T. GALLOWAY, B.Agr.Sc., LL.D., Director.
ALBERT R. MANN, B.S.A., Secretary.
JOHN H. COMSTOCK, B.S., Entomology.
HENRY H. WING, M.S. in Agr., Animal Husbandry.
T. LYTTLETON LYON, Ph.D., Soil Technology.
JOHN L. STONE, B.Agr., Farm Practice.
JAMES E. RICE, B.S.A., Poultry Husbandry.
GEORGE W. CAVANAUGH, B.S., Agricultural Chemistry.
HERBERT H. WHETZEL, M.A., Plant Pathology.
ELMER O. FIPPIN, B.S.A., Soil Technology.
G. F. WARREN, Ph.D., Farm Management.
WILLIAM A. STOCKING, Jr., M.S.A., Dairy Industry.
CHARLES S. WILSON, A.B., M.S.A., Pomology.
WILFORD M. WILSON, M.D., Meteorology.
RALPH S. HOSMER, M.F., Forestry.
JAMES G. NEEDHAM, Ph.D., Entomology and Limnology.
ROLLINS A. EMERSON, Ph.D., Plant Breeding.
HARRY H. LOVE, Ph.D., Plant Breeding.
ARTHUR W. GILBERT, Ph.D., Plant Breeding.
DONALD REDDICK, Ph.D., Plant Pathology.
EDWARD G. MONTGOMERY, M.A., Farm Crops.
WILLIAM A. RILEY, Ph.D., Entomology.
MERRITT W. HARPER, M.S., Animal Husbandry.
J. A. BIZZELL, Ph.D., Soil Technology.
GLENN W. HERRICK, B.S.A., Economic Entomology.
HOWARD W. RILEY, M.E., Farm Mechanics.
CYRUS R. CROSBY, A.B., Entomology.
HAROLD E. ROSS, M.S.A., Dairy Industry.
KARL McK. WIEGAND, Ph.D., Botany.
WILLIAM H. CHANDLER, M.S. in Agr., Pomology.
EDWARD A. WHITE, B.S., Floriculture.
ELMER S. SAVAGE, M.S.A., Ph.D., Animal Husbandry.
LEWIS KNUDSON, Ph.D., Plant Physiology.
KENNETH C. LIVERMORE, B.S. in Agr., Farm Management.
ALVIN C. BEAL, Ph.D., Floriculture.
MORTIER F. BARRUS, Ph.D., Plant Pathology.
CLYDE H. MYERS, M.S., Ph.D., Plant Breeding.
GEORGE W. TAILBY, Jr., B.S.A., Superintendent of Live Stock.
EDWARD S. GUTHRIE, M.S. in Agr., Ph.D., Dairy Industry.
JAMES C. BRADLEY, Ph.D., Entomology.
PAUL WORK, B.S., A.B., Vegetable Gardening.
JOHN BENTLEY, Jr., B.S., M.F., Forestry.
EARL W. BENJAMIN, Ph.D., Poultry Husbandry.
EMMONS W. LELAND, B.S.A., Soil Technology.
CHARLES T. GREGORY, Ph.D., Plant Pathology.
WALTER W. FISK, M.S.A., Dairy Industry.
ARTHUR L. THOMPSON, M.S. in Agr., Farm Management.
ROBERT MATHESON, Ph.D., Entomology.
HORACE M. PICKERILL, B.S., Dairy Industry.
MORTIMER D. LEONARD, B.S., Entomology.
FRANK E. RICE, Ph.D., Agricultural Chemistry.
VERN B. STEWART, Ph.D., Plant Pathology.
IVAN C. JAGGER, M.S., Plant Pathology (In cooperation with Rochester University).
CHARLES H. HADLEY, B.S., Entomology.
BRISTOW ADAMS, B.A., Editor.
LELA G. GROSS, Assistant Editor.

The regular bulletins of the Station are sent free on request to residents of New York State.

Ithaca, New York, February 9, 1915

DIRECTOR B. T. GALLOWAY,
College of Agriculture,
Ithaca, New York.

Dear Sir:

In accordance with the terms of the Industrial Fellowship agreement with the C. W. Stuart Company, of Newark, New York, and with the terms of the Investigatorship agreement with the nursery firms of C. W. Stuart Company of Newark, New York, Chase Brothers Company of Rochester, New York, Brown Brothers of Rochester, New York, and Jackson & Perkins of Newark, New York, I beg to submit herewith a report of investigations of some important leaf diseases of nursery stock with the recommendation that it be published as Bulletin 358 of the Cornell University Agricultural Experiment Station.

The work has been done by Professor V. B. Stewart, and represents experimental work and investigations extending from the year 1909 to the present time. During the summer months the work has been done in the nurseries of the firms mentioned above; much of it in the C. W. Stuart Nursery at Orleans, New York, and the Chase Brothers Nursery at Honeoye Falls, New York.

Respectfully submitted,
H. H. WHETZEL,
Professor of Plant Pathology.

Digitized by the Internet Archive
in 2025

https://archive.org/details/bulletin-cornell-agricultural-experiment-station_1915-04_358

CONTENTS

	PAGE
Introduction	171
Spray mixtures	174
Spraying machines	176
Apple scab and pear scab	178
Symptoms	180
Cause	180
Life history	180
Control	181
Apple powdery mildew	181
Symptoms	182
Cause	182
Life history	182
Control	183
The yellow-leaf disease of cherry and plum	184
Occurrence on different hosts	184
Symptoms	185
Cause	186
Life history	187
Control	189
Powdery mildew of cherry	192
Symptoms	193
Control	194
Anthracnose of currants and gooseberries	194
Occurrence on different hosts	194
Symptoms	195
Cause	196
Life history	196
Control	197
Septoria leaf-spot of currants and gooseberries	198
Symptoms	198
Cause	198
Life history	199
Control	200
The gooseberry mildew	200
Symptoms	201
Cause	201
Life history	201
Control	202
Leaf-blotch of horse-chestnut	202
Symptoms	203
Cause	204
Life history	204
Control	205
Peach leaf-curl	205
Varietal susceptibility	206
Symptoms	207
Cause	209
Life history	209
Control	210
Leaf-blight of pear and quince	212
Occurrence on different hosts	212
Symptoms	212
Cause	214
Life history	214
Cross inoculations	214
Cratægus on pear and quince	214
Pear on quince and Cratægus	215
Quince on pear	215
Control	215

PAGE
Septoria leaf-spot of the pear 216
Symptoms 217
Cause 218
Life history 218
Control 218
Black spot of roses 219
Varietal susceptibility 219
Symptoms 220
Cause 220
Life history 220
Control 221
Mildew of rose and peach 221
Varietal susceptibility 222
Symptoms 223
Cause 224
Life history 224
Control 224

SOME IMPORTANT LEAF DISEASES OF NURSERY STOCK

VERN B. STEWART

INTRODUCTION

It is the purpose to discuss briefly in this bulletin the various diseases affecting the foliage of nursery stock as grown in New York State, and, as far as possible, to offer suggestions for prevention. The nursery business is a somewhat specialized industry, and only a very few students of phytopathology have had an opportunity to devote much of their attention to diseases as found in nursery plantings. This has been the situation particularly throughout the past fifteen years. Previous to that time some of the pioneer pathologists of this country conducted numerous investigations for the control of leaf diseases of nursery stock. Among these were B. T. Galloway, D. G. Fairchild, and F. L. Scribner, working for the United States Department of Agriculture. L. H. Pammel, of the Iowa Agricultural Experiment Station, also experimented on the control of various diseases appearing in the nurseries of Iowa. The work of these men covered a period of years and is of much importance, especially that of Doctors Galloway and Fairchild, who conducted most of their investigations in the nursery district around Geneva, New York. Many of the methods of control suggested by these investigators are still in use to-day, and have been very effective in reducing the annual losses suffered by nurserymen because of diseased stock.

The nursery business is one of the most important specialized agricultural industries of New York State. The growing interest in landscape gardening and the tendency toward more extensive orchard planting have caused a rapid growth in the nursery industry of this country. The figures recently published in this connection by the Division of Statistics, Bureau of the Census (1912), are of special interest. The total value of nursery products reported from 5582 establishments in 1909 was $21,051,000; this was an increase of 591 establishments, or 11.8 per cent, and $10,927,000, or 107.9 per cent, in ten years. In 1909 the Middle Atlantic States ranked first, with products valued at $4,355,000 as compared with $2,523,000 in 1899 — an increase of $1,832,000, or 72.6 per cent, during the decade from 1899 to 1909. Although the number of establishments reporting nursery products was greatest in the northeastern Central States, being here 1159, this section ranked fourth in value of products, being excelled by the Middle Atlantic, northwestern Central, and Pacific divisions. In percentage of income the Pacific States ranked

(1912) Press notice, Division of Statistics, Bureau of the Census. June 25, 1912.

first, with 377 per cent; the southwestern Central States second, with 179.4 per cent; and the south Atlantic States third, with 117.4 per cent.

The three States ranking highest in value of nursery products in 1909 were: New York, $2,751,000; California, $2,213,000; and Texas, $1,253,000. The order in 1899 was New York, Iowa, Illinois. An increase in value of nursery products is reported from all States except Maine, Vermont, Virginia, and South Carolina; no increase is reported from the District of Columbia. In the State of Washington the value of products in 1909 was almost twenty times as great as that in 1899.

The nursery business, like all industries, demands attention directed along certain lines that tend to promote its progress and advancement. The important problem confronting nurserymen of to-day is the production of the greatest amount of first-class stock per acre of land within the shortest period of time. The market sets certain standards of quality and size, and in order that a financial gain may be realized the development of this stock must be encouraged so that it will be marketable as soon as possible. Such conditions as weather, soil, amount of cultivation, and presence of certain destructive diseases, are some of the factors that influence the development of nursery plantings. Of particular importance is the effect of various plant diseases and insects. The stock may have developed very rapidly and be perfectly healthy, when within a very short time conditions may change and the plants become seriously injured or totally ruined by some destructive disease or insect.

The losses in the nursery caused by diseases are often very heavy. Some diseases, such as fire blight, completely destroy the stock attacked unless the disease is eradicated by cutting out the affected parts. Other diseases affect only the foliage and are a menace to nursery stock by causing the leaves to fall prematurely, thus retarding the development and growth of the plants. Not only does this condition make it necessary for a longer time to elapse before the stock is salable, but premature defoliation also prevents proper maturation of the trees and makes them less able to withstand winter injury, adverse conditions encountered in storage, and the like.

The control of leaf diseases in nursery stock offers a problem for special consideration. Methods commonly practiced for the prevention of diseases of older and maturer plants are in many cases not applicable to the smaller stock in the nursery, while, on the other hand, in many cases certain methods of control can be carried out in the nursery which could not be used in the treatment of mature plants. The latter condition is particularly emphasized in the control of diseases affecting such stock as roses or currants. Applications of fungicides that mar the beauty of the rose blossoms are permissible only in the nursery, where

blossoms are not desired owing to their tendency to check the development of the young bushes. Currants in the nursery can be sprayed at any time; on the other hand, for older bushes it is not desirable to spray with a fungicide that will be apparent on the fruit when it is picked for the market.

The prevalence of certain diseases also differs with the age of the host plant. One of the most important diseases of orchard trees is the well-known scab, and every year it is necessary to spray as a protection against this, while in the nursery the same disease is seldom of any great economic importance. The susceptibility or resistance to disease of seedlings and budded stock of different ages is likewise worthy of consideration. Some diseases may become localized and be exceedingly prevalent in one nursery, while in another nursery district the same diseases cause but little damage. A satisfactory means of applying the spray mixture also demands special attention. All these factors are of much significance in the control of nursery diseases. They require methods particularly applicable to the conditions that exist, and in many respects differ from the ordinary procedure followed by the pathologist in his attempt to check these destructive parasites.

A large proportion of the leaf diseases affecting nursery stock are caused by the low group of plants known as fungi. Many species of fungi are parasitic, living on other plants from which they obtain their food and nourishment. The plant attacked by the parasite is commonly designated as the host. In an effort to obtain food, the activities of the fungi are usually such as to cause severe injury to the cells of the host plant and certain parts of the plant tissue are killed. When a fungus attacks the foliage, so much of the tissue may be injured that the leaves are no longer able to function in the manufacture of food for the plant and fall prematurely to the ground.

The usual means of protecting the foliage from attacks of these parasitic fungi is by covering the leaf surface with a fungicide, or spray mixture which is highly poisonous to the fungus. In spraying for the prevention of a disease it is necessary to keep in mind the relations existing between the host plant and the fungus causing the disease. In general, conditions of rainfall and temperature that influence the host affect also, to some extent, the activities of the fungus. Each rainy period of an ordinary summer season favors the growth of the host plant, since sufficient moisture is supplied for its development. On the other hand, wet weather also affords necessary conditions for the parasite. Unless moisture is present, the fungus spores, by means of which the parasite is propagated, are unable to germinate and produce infection when they fall on the leaves of the host plant.

Various kinds of spores require different amounts of moisture, but in general the fungi causing leaf diseases produce the greatest damage when a rainfall is followed by damp, cloudy weather for a period of twenty-four hours or longer. Drops of water falling on the leaves supply the spores with moisture for germination. The spore sends out a germ tube, which penetrates the leaf tissue within a few hours, and is soon able to extract its nourishment from the affected tissue and thus continue its growth.

After the spore has germinated and the germ tube has gained an entrance into the tissue, it is impossible to check the fungus. For the prevention of the disease, therefore, it is necessary to check the parasite in its attacks before it can establish itself in the host. It is by means of the fungicides applied to the healthy foliage before the conditions are suitable for the development of the fungus, that the latter is kept in check. When the spore germinates, the germ tube comes in contact with the poison, is killed, and thus fails to produce an infection.

Unsuccessful attempts to control certain diseases may often be due to failure to apply the spray mixture at the proper time. It is necessary to make the application at such intervals as will afford the greatest protection to the foliage throughout the growing season. A thorough spraying will protect the leaves for a considerable length of time, but it will not be of any value to the foliage developed subsequently. As long as growth continues the new leaves must be sprayed shortly after they appear. The rate of growth of the host plant, along with the weather conditions, determines the time for the applications of the fungicide. With prolonged periods of dry weather the plants do not grow so rapidly and the time interval between certain sprayings may be somewhat lengthened as compared to seasons when wet weather prevails.

It is of extreme importance to remember that in order to insure protection to new foliage, the fungicide must be applied *before* the rains, not after. The *fungicides are not washed off by the rains*, but, on the other hand, when the leaves are thoroughly covered, the poisonous compound acts as a preventive against the attacks of the germinating spores during damp, cloudy weather. Spraying should never be deferred or discontinued for fear that the fungicide will be washed off; it dries rapidly, and when dry a sufficient amount remains to afford protection against the fungous parasite even after continued heavy rainfall.

SPRAY MIXTURES

Bordeaux mixture has been the standard spray mixture used in the nursery for many years and is very effective against most leaf diseases. The mixture may be made by the grower, or it may be bought on the market in the prepared form known as bordeaux paste or powder. Home-

made bordeaux mixture is preferable, since it remains in suspension somewhat longer than the market mixture, and it also has better sticking qualities when applied to the foliage. Considerable objection to the use of bordeaux mixture has been raised from time to time owing to the injury or burning of certain foliage, particularly that of plums. Serious damage to plum nursery stock has been reported occasionally. The formula most commonly used for making bordeaux mixture is 5 pounds of stone lime, freshly slaked, and 5 pounds of copper sulfate (blue vitriol), to 50 gallons of water.

Lime-sulfur solution has been substituted in recent years for bordeaux mixture in the control of several diseases. This solution also may be made by the grower, but unless ample facilities are at hand it is preferable, for nurserymen at least, to use commercial lime-sulfur solution, which can be bought in a concentrated form. This solution may also cause burning of the foliage unless care is taken not to apply the solution in too concentrated a form. Lime-sulfur solution is easier to handle than bordeaux mixture and it has proved more effective in the control of certain diseases, especially the mildews. The strength of lime-sulfur solution to be used varies, depending on the host plant and to some extent on the fungus causing the disease.

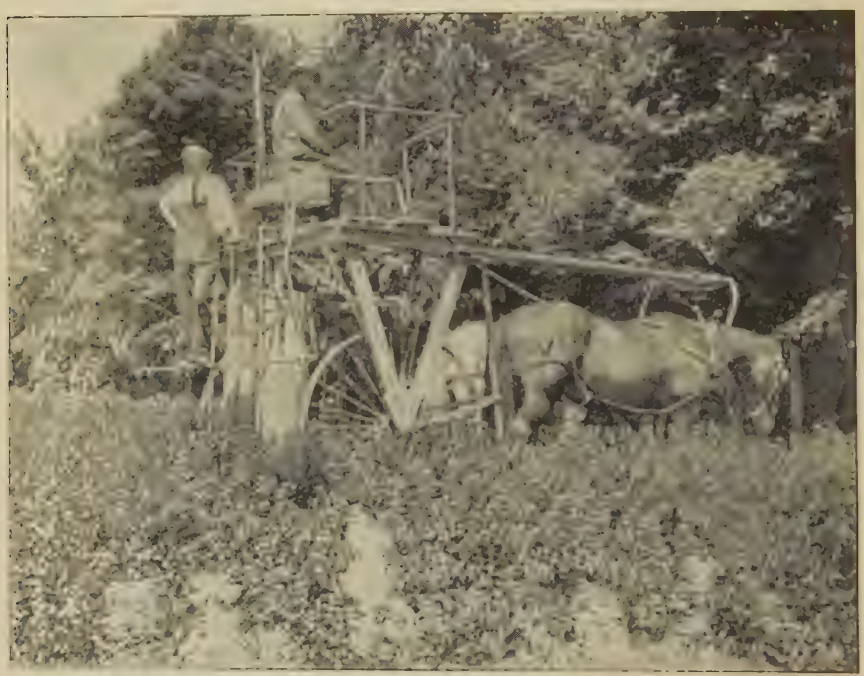
The addition of granulated iron sulfate to lime-sulfur solution has been of value in some cases. The iron sulfate reduces the danger of burning, and the mixture formed has better sticking qualities, especially if it is applied at a low pressure or with a gas spraying machine. Iron sulfate appears to slightly reduce the efficiency of lime-sulfur solution for some diseases by changing the composition of the mixture, but this has not been of sufficient importance to be considered. On the other hand, the addition of iron sulfate apparently increases the efficiency of the solution in the control of certain mildews, such as those that attack apple and rose stock. Iron sulfate added to lime-sulfur solution causes a black, muddy precipitate to be formed. This precipitate, which gradually settles to the bottom, contains precipitated sulfur, iron sulfide, and calcium sulfate. It is the precipitated sulfur in the mixture which has the valuable fungicidal properties.

Dusting with sulfur is effective in checking certain diseases, such as some of the mildews. Considerable experimental work has been conducted in order to determine the value of dusting for other orchard diseases; but the results thus far obtained do not warrant the adoption of this method for the general control of nursery diseases, although the perfection of a dust mixture would eliminate many of the difficulties encountered at the present time in the attempt to check these diseases in the nursery.

SPRAYING MACHINES

One of the important problems confronting nurserymen is a satisfactory means of applying spray mixtures. An apparatus is desirable which will apply the spray with sufficient force and with the least inconvenience, permitting the work to be done with considerable rapidity and as economically as possible.

Numerous hand sprayers (Fig. 86, page 211) are in use which can be used for small plantings, but there is no power machine on the market that



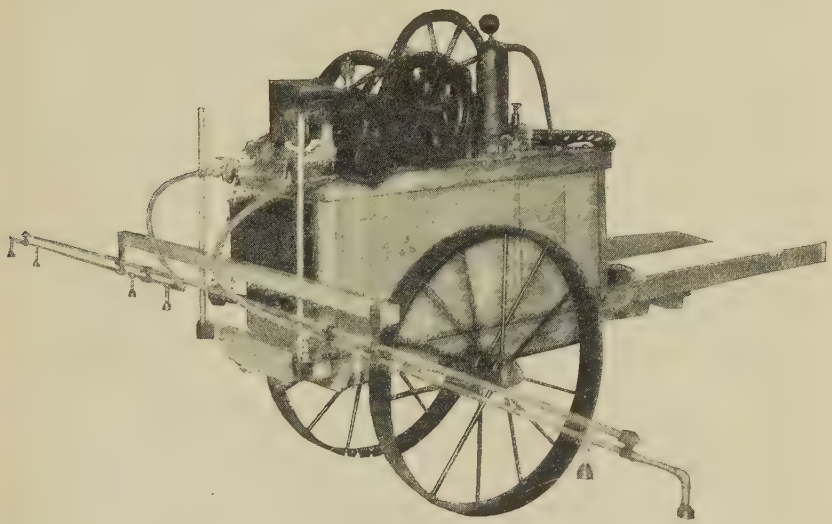
PHOTOGRAPH BY D. GUNN

FIG. 66.—*A two-horse gas-power sprayer for spraying all stock below six feet in height*

is entirely satisfactory for nursery work. It has been difficult to construct a machine that can be transported over tall stock and at the same time will be practicable. The practical sprayer for the nursery is a two-horse-power machine built to spray at least four rows of large stock and equipped with a container that will hold at least 75 gallons of the spray mixture. It should be easy to transport, and should be provided with a device that will furnish the necessary pressure for spraying. The power for spraying machines has usually been supplied by traction, gasoline engines, compressed air tanks, or compressed carbonic acid gas.

A two-horse gas-power machine for spraying all stock below six feet in height is illustrated in figure 66. This machine straddles two rows, and has two 50-gallon steel tanks suspended between the rows as containers of the spray mixture. The power is furnished by compressed carbonic acid gas. The gas is procured in steel drums and the spraying may be done with any pressure desired.

The greatest objection to this sprayer is its bulkiness and the effect of the carbonic acid gas on certain of the spray mixtures, such as lime-sulfur solution. The gas precipitates the sulfur in the lime-sulfur solution, reducing the efficiency of the solution as an insecticide when used for



PHOTOGRAPH BY W. C. AKINS MACHINE COMPANY

Fig. 67.— *A sprayer built to run between nursery rows. The width of the sprayer from hub to hub is twenty-eight inches. The power is furnished by a gasoline engine*

San José scale or other scale insects. On the other hand, the carbonic acid gas does not affect the fungicidal properties of the solution; the precipitated sulfur is practically as effective as the lime-sulfur solution, but it does not stick so well to the foliage. The sticking qualities, however, can be increased considerably by the addition of iron sulfate.

The machine illustrated in figure 67 is a sprayer constructed to go between the nursery rows. The width from hub to hub is twenty-eight inches, giving a clearance in the nursery row of fourteen inches. One horse, or two horses driven tandem, can be used. The containing tank holds 75 gallons and the power is furnished by a gasoline engine. Four rows at a time can be sprayed, and the spray boom, with two or

three nozzles to a row, is adjustable to any height necessary. When the machine is used for dormant spraying, trailers may be substituted for the spray boom. Three or four attachments of hose, from twelve to twenty feet in length, with nozzles, are carried by men who follow behind the sprayer, each man with a trailer spraying a single row. The trailers make it possible to cover the trees more thoroughly, and are especially desirable in spraying to prevent peach leaf curl and San José scale.

This sprayer is an improvement on the machine illustrated in figure 66, in that it is not so cumbersome and is less expensive to operate, and in that the spray mixture is not affected by the carbonic acid gas when the latter is used for pressure. On the other hand, this sprayer has proved to be top-heavy when used on unlevel ground. This difficulty could undoubtedly be overcome by changing the dimensions of the container and mounting it on a four-wheeled platform. By reducing the height of the container and increasing the length, the machine would not upset so easily.

APPLE SCAB AND PEAR SCAB

The diseases known as scab are called also black spot, scurf, or the fungus. The name *scab* is used almost exclusively in the United States. These diseases apparently exist in every country where apples and pears are grown commercially. They are widely distributed in the United States, and in seasons favorable to them the annual losses in New York orchards due to apple scab alone are estimated by Wallace (1913) at over three and one-half million dollars.

In the nursery, pear scab commonly affects the Flemish pear buds, and when conditions are favorable to the disease almost complete defoliation of the trees may result in midsummer. The twigs and the young shoots also are usually affected, causing the branches to make a stunted growth. Several blocks of two-years-old pear stock have been observed by the writer, of which the Flemish variety was so badly affected by the scab that only from about five to ten per cent of the trees calipered first-class (XXX) when dug in the autumn. The other varieties were not noticeably affected by the disease.

The apple scab is most commonly found in the nursery on the Transcendent crab. Frequently considerable defoliation in this variety may result from the disease. Other varieties of apples are occasionally affected. In the season of 1913 there was a severe epiphytotic of the apple scab disease in one of the large nurseries of New York State, and all varieties were somewhat affected. The disease was most serious in the two-years-

(1913) Wallace, Errett. Scab disease of apples. New York (Cornell) Agr. Exp. Sta. Bul. 335 : 541–624.

PHOTOGRAPH BY E. WALLACE

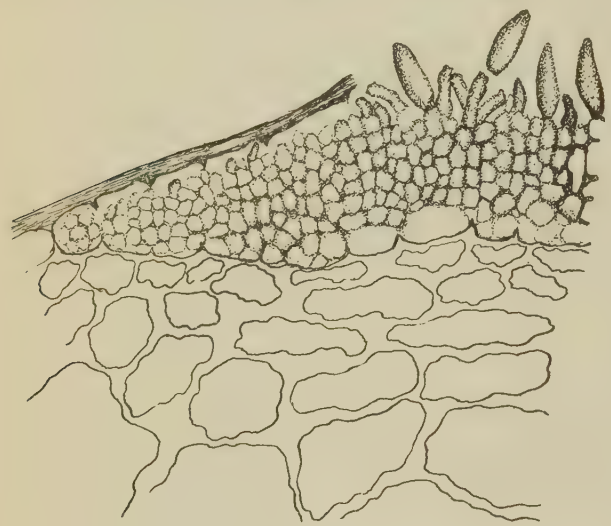
FIG. 68.—*Apple-scab disease on leaves. The second and third leaves from the left show the lesions on the under surface*

old budded McIntosh trees. Heavy defoliation resulted, and shoots and twigs were so badly diseased that very few of the trees made sufficient growth to be salable as first-class (XXX) stock when dug in the autumn.

Symptoms

The leaves (Fig. 68) and the fruit, and occasionally the twigs, are affected. The scab is likely to appear earliest on the under surface of the leaves. The diseased area is at first olivaceous in color and slightly darker than the normal leaf. Later the scab spots become darker, changing to brown and finally to nearly black. There is a tendency for the lesions to extend along the veins of the leaf, making them somewhat irregular in appearance. When the disease is very pronounced both surfaces of the leaf may be covered with the dark olive-colored lesions, and in some cases curling or distortion of the foliage may result.

On the twigs the bark becomes blistered, and later ruptured in places, causing a scurfy appearance.



PHOTOGRAPH BY E. WALLACE

FIG. 69.— *Conidial stage of apple-scab fungus. The section, through a scab spot on a leaf, shows the fungous stroma located beneath the cuticle and in the epidermal cells. The growth of the fungus lifts the cuticle of the leaf*

Cause

The fungous parasites causing the apple scab and pear scab are almost identical in appearance. The species on the apple is known as *Venturia inæqualis* (Cke.) Wint., and that on pears as *Venturia pyrina* Aderh.

Life history

On the scab spots caused by these fungi a large number of spores (Fig. 69) are produced, which, being very small, are disseminated by wind and rain. Falling on the fruit and the leaves of the host plant, these spores produce new infections when moisture is present and are a means of propagating the fungi throughout the summer.

On the diseased leaves that fall to the ground in autumn, special fruiting bodies (perithecia) are produced, which are resistant to cold and bridge the fungi over winter. In the early spring numerous sac-like bodies, asci, bearing eight spores, are developed in the perithecia. These ascospores are discharged during periods of damp, cloudy weather about the time when the leaves begin to open, and, carried by wind and rain, they fall on the newly developed foliage, where they produce the first infection of the season. From twelve to fourteen days after the spores attack the foliage the characteristic scab lesions begin to appear.

Control[1]

Bordeaux mixture and lime-sulfur solution are both effective for the control of the scab diseases on apple and pear. In recent years lime-sulfur solution has been used almost exclusively by orchardists for apple scab. The standard strength used is 1 to 40. In many cases bordeaux mixture causes some injury by burning fruit and foliage; but, on the other hand, for pear scab it is advisable to use bordeaux mixture, since lime-sulfur solution occasionally causes severe burning of pear foliage when used at a strength that will control the scab.

For nursery stock the first spraying should be done soon after the first new leaves are put forth. This application should be followed by at least two more sprayings at intervals of from two to three weeks. If the season is very wet, one or two more applications are advisable in most instances.

As a general recommendation for the nurseries of New York State, it is not considered necessary to spray varieties of pears for scab except the Flemish. The trees of this variety are so commonly affected that spraying each season is beneficial. In most nurseries it is not necessary to spray each year for apple scab, but in some instances spraying would be exceedingly beneficial. Where the disease is commonly observed on certain varieties of apples such as Transcendent crab, spraying is advisable.

APPLE POWDERY MILDEW

Cherry, plum, pear, and quince stock are occasionally affected by powdery mildew, but this disease is most commonly observed in the nursery on the foliage and the young shoots of the apple seedling stock. When it appears early in the summer, the growth of the seedlings is checked and the bark does not peel readily at budding time. The budded apple stock is sometimes affected and severe epiphytotics of the disease have been known to occur in bearing apple orchards.

[1] Dusting with dry sulfur for scab control (See New York [Cornell] Agr. Exp. Sta., Bul. 354, 1915, by Donald Reddick and C. R. Crosby) has proved effective to a considerable degree in certain experimental orchards where it has been tried, but as yet the results obtained do not warrant the general adoption of this method as a means of preventing scab.

Symptoms

The foliage and the young twigs are affected, and in extremely rare cases the disease occurs on the fruit of apples. The grayish white, feltlike areas are commonest at first on the underside of the leaf, and vary in size from a minute speck to an inch in diameter; later the mildew may appear on the upper surface, involving the entire leaf. The diseased leaves are stunted, are somewhat narrower in width than the healthy leaves, and have a tendency to crinkle and curl up.

Affected shoots are much shorter than they would be normally. There is a shortening of the internodes, and in many cases an increase in thickness of the diseased twigs may be noticed. Small black specks are commonly observed in the white areas on the twigs.

The ends of the diseased shoots die back in winter, causing the production of numerous lateral shoots in the following spring. The old grayish white patches of mildew are often very apparent on the twigs throughout the winter.

Cause

The disease may be caused by either of two fungous parasites, *Podosphæra oxyacanthæ* (DC.) de Bary or *Podosphæra leucotricha* (E. & E.) Salm. These two species are very closely related, and only a microscopic examination of the sexual stage (the black specks referred to above) enables one to definitely distinguish them. *P. oxyacanthæ* is found very commonly on cherries, but, in the United States at least, the organism attacking apples is in the greater majority of cases *P. leucotricha*. F. C. Stewart (1910) examined specimens of apple mildew from various sections of New York State and all of them proved to be *P. leucotricha*. At the same time the writer also examined specimens of the apple mildew collected in several nurseries of the State, and all were of the same species, *P. leucotricha*. Ballard and Volck (1914) state that the apple powdery mildew in the Pajaro Valley of California is caused by *P. leucotricha*.

Life history

The grayish, feltlike patches of mildew on the leaf or the shoot consist of a tangle of fine threads, or strands, of the fungus. This loosely interwoven mass of threads is known as mycelium. From certain strands of the mycelium, stalks are sent up which bear large numbers of conidia, or summer spores (Fig. 94, page 225). The spores, being very minute, are carried by wind and rain to other leaves, where under favorable conditions they germinate and produce new patches of mildew. The fungus obtains

(1910) Stewart, F. C. Notes on New York plant diseases. New York (Geneva) Agr. Exp. Sta. Bul. 328: 320-321.

(1914) Ballard, W. S., and Volck, W. H. Apple powdery mildew and its control in the Pajaro Valley. U. S. Agr. Dept. Bul. 120: 1-26.

its nourishment by sending suckerlike bodies, haustoria, into the epidermal cells of the leaf. After midsummer reproductive bodies, known as perithecia (Fig. 70), are also produced in the mass of mycelium. These perithecia appear to the naked eye as the small black specks previously mentioned, and they serve to bridge the fungus over winter. In the following spring or early summer each perithecium discharges an ascus (Fig. 70), which contains eight ascospores. Falling on the newly developed foliage, the ascospores germinate and produce the first infections of the season, resulting in the appearance of the mildew a few days later.

Ballard and Volck (1914) and other investigators are of the opinion that the fungus lives over winter in the dormant buds also. The following is quoted from Ballard and Volck (page 9 of reference cited): "Careful observations have led the writers to the conclusion that in the Pajaro Valley this method [by means of perithecia] of bridging over the winter season amounts to practically nothing in the matter of starting the first infections of the following year. It may be that relatively a very small percentage are established by this means, but the really important source is in what the writers have termed the dormant-bud infections. It can be easily seen that in such serious twig infections ....., the mildew growing over the surface of the shoots has an excellent opportunity to work its way in between the bud scales and penetrate both the lateral and terminal buds. This actually happens, and within these buds the mildew passes the winter in a dormant condition. The following spring, as the infected buds begin to open, the mildew commences to grow and keeps pace with the development of the new twigs."

Fig. 70.—*Perithecium of the apple mildew fungus, showing the two types of appendages. Within the perithecium is a single ascus which contains eight ascospores (shown at the right)*

Control

Bordeaux mixture and other copper sprays are not satisfactory fungicides for the control of most mildew diseases (Galloway, 1889). This is particularly true of the apple powdery mildew (Fairchild, 1893). Lime-sulfur solution is effective to a certain degree, but the addition of iron

(1889) Galloway, B. T. Experiments in the treatment of pear leaf-blight and the apple powdery mildew. U. S. Agr. Dept., Veg. Path. Sec. Circ. 8:1–11.
(1893) Fairchild, D. G. Experiments in preventing leaf diseases of nursery stock in western New York. Apple powdery mildew. Journ. myc. 7:256.
(1914) Ballard, W. S., and Volck, W. H. Apple powdery mildew and its control in the Pajaro Valley. U. S. Agr. Dept. Bul. 120:1–26.

sulfate makes a mixture that is more satisfactory for the control of the disease. The precipitation caused by the iron sulfate converts the sulfur into a more finely divided form, which apparently has a better covering power and also sticks better to the foliage than does the lime-sulfur solution alone.

Lime-sulfur, 1 gallon to 50 gallons of water, plus 3 pounds of iron sulfate, has proved satisfactory for the control of apple powdery mildew in the nurseries of New York State. The first application should be made soon after the seedlings have developed the first new shoots. Three or four subsequent sprayings should be made at intervals of from two to three weeks.

In some seasons apple nursery stock, in New York State at least, is practically free from the mildew, while in other years the disease is very destructive. Therefore the number of sprayings required to keep the mildew in check depends on the season, and the control methods should be in accordance with the conditions that exist. Where the disease is prevalent an effort should be made to keep as much as possible of the new growth covered with the spray.

THE YELLOW-LEAF DISEASE OF CHERRY AND PLUM

Leaf blight, commonly known also as yellow leaf, or shot-hole, of plums and cherries, is one of the most important of the diseases affecting nursery stock. It was first reported in Europe in 1884 on *Prunus padus*, and has been common there on both sweet and sour cherries for the past twenty years. In America the disease has been reported on nearly all species of Prunus, both wild and cultivated. It is found in all the nursery districts of the United States where cherry and plum stock is grown, and may be very destructive to nursery trees when weather conditions are favorable.

Occurrence on different hosts

Usually the disease is found in abundance on the sweet cherry, *Prunus avium*, and on the wild chokecherry, *Prunus virginiana*. It is common on sour cherries, *Prunus domestica*, *Prunus institia*, and *Prunus spinosa*. The leaves of *Prunus serotina* also are known to have been affected.

In the nurseries of New York State the susceptibility of cherry and plum seedlings to the disease is of considerable importance. Mazzard cherry seedlings are very susceptible, and often they are so badly defoliated that it is impossible to bud the trees. Mahaleb cherry seedlings are affected to some extent, but ordinarily the damage is less than on mazzards. Myrobalan plum seedlings show a considerable degree of resistance and, at least in New York State, are seldom affected.

The varieties of sweet cherries are more seriously affected than are the sour cherries. Often, however, the disease is very destructive to all varieties of cherries and may cause a heavy loss of foliage. Varieties of European plums also may be defoliated completely by the disease in a season of abundant rainfall (Stewart, 1914). Japanese plums are more resistant, and the disease is of little importance on these varieties.

Symptoms

The leaves, the fruit, and the fruit pedicels may be affected, but generally the lesions are confined to the foliage and their appearance

FIG. 71.— *Shot-hole effect on plum leaves affected with the yellow-leaf disease*

on the fruit is rather uncommon. The disease is first noticed in the latter part of May or in early June. On certain hosts it becomes very evident because of the shot-hole appearance of the leaves, which is brought about by the dropping-out of the circular areas of affected tissue (Fig. 71). The shot-hole effect is commonest on plum varieties, in which the perforations may be so abundant that, owing to the dropping-out of the diseased areas, only remnants of the leaves are left. Infections on the Japanese plum varieties are of a shot-hole nature, but there is practically no defoliation as in the case of the European plum varieties. It is believed

(1914) Stewart, V. B. The yellow-leaf disease of cherry and plum in nursery stock. New York (Cornell) Agr. Exp. Sta. Circ. 21 : 1–10.

that the larger part of the shot-hole effect on these varieties is caused by an insect.

On the leaves of cherries the diseased spots do not drop out so readily. They first appear on the upper side of the leaf as slightly discolored areas, usually not exceeding an eighth of an inch in diameter and more commonly about half that size. Later, after a period of seven to ten days, they become definite lesions, dark red or reddish brown in color. The infection may be confined to a small section of the leaf, but in many cases the red spots indicating the diseased areas are thickly scattered over the entire

FIG. 72.—*Sweet-cherry leaves affected with the yellow-leaf disease, showing the dark red spots and also the yellow discoloration*

leaf (Fig. 72). In the advanced stages a yellowing of the affected foliage may occur and the leaves may fall prematurely.

The same yellowing sometimes appears on plum leaves, but never so abundantly as on sweet-cherry foliage.

Particularly in periods of wet weather, small, white, velvety pustules may be observed on the undersides of the leaves, opposite the discolored spots. Occasionally these pustules appear also in the center of the lesions on the upper side of the leaf.

Cause

In 1884 P. A. Karsten described the organism *Cylindrosporium padi*, and the yellow-leaf disease on *Prunus padus* in Europe was attributed

to this fungus. Higgins (1913) discovered the sexual stage of the Cylindrosporium on *Prunus avium* and named the fungus *Coccomyces hiemalis*. Further studies by Higgins (1914) show that there are at least three species of Cylindrosporium parasitic on species of the genus Prunus. The morphological differences of the sexual forms, along with cross inoculations, led Higgins to make the following distinctions:

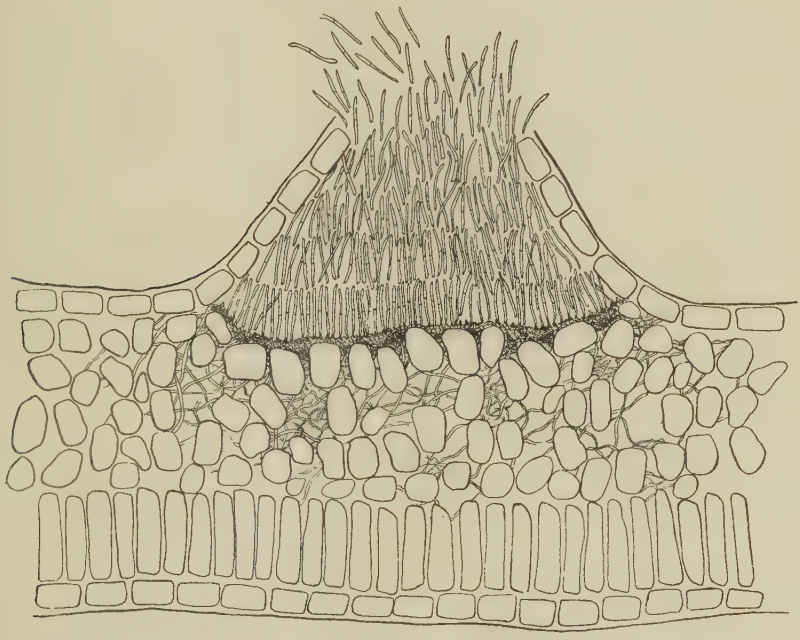


FIG. 73.— *Cross section of cherry leaf through an acervulus of the Cylindrosporium fungus. The epidermal cells of the leaf have been pushed up and broken, permitting the spores to escape*

Coccomyces hiemalis Higgins on *Prunus avium*, *P. cerasus*, and *P. pennsylvanica*

Coccomyes prunophoræ H. on *Prunus americana*, *P. domestica*, and *P. institia*

Coccomyes lutescens H. on *P. serotina*, *P. virginiana*, and *P. mahaleb*

Life history

With the active growth of the fungus in the leaf tissue, the mycelial threads of the fungus form a closely packed mass near the surface of the leaf, resulting in the formation of a fruiting body (Fig. 73). The number

(1913) Higgins, B. B. The perfect stage of Cylindrosporium on Prunus avium. Science 37 : 637-638.
(1914) Higgins, B. B. Contribution to the life history and physiology of Cylindrosporium on stone fruits. Amer. journ. bot. 1 : 145-173.

of spores produced is usually very great, and on being pushed out on the undersurface of the leaf they form the white pustules previously described. The spores, being very minute, are easily carried to the leaves by the wind and rain, and are thus disseminated over a considerable distance. Falling on a leaf, the spore germinates (Fig. 74) if moisture is present, the germ tube penetrates the tissue of the leaf, and with continued growth it develops a mycelium with many branches. These branches extend between the cells of the leaf, often penetrating them or sending suckerlike branches into them. The affected areas become disorganized, and in this way the mycelium derives its nourishment from the leaf. The attacked cells turn brown, and as the mycelium extends farther into the tissue the discoloration increases, resulting in the formation of the reddish-colored spots previously described. When a number of germ tubes attack the same leaf, a large part of it becomes affected; the living substance is destroyed and the leaf drops prematurely, being no longer able to function in the manufacture of food for the tree.

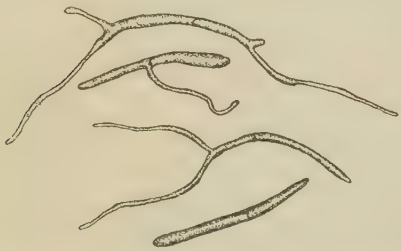


FIG. 74.— *Spores of the Cylindrosporium fungus, some of which have germinated. Highly magnified*

Throughout the summer the disease continues to spread with each period of wet weather, and as the new foliage develops it is in constant danger of infection. Often the trees may be defoliated completely by the latter part of August and the ground may be covered with diseased leaves. It is in these old, affected leaves that the fungus lives over winter. By the formation of the sexual fruiting body (Fig. 75) within the leaf tissue the organism is able to withstand the severe cold weather of the winter months. During periods of abundant rainfall in the following spring, when the trees are developing the first new leaves, these specialized fruiting bodies (known as apothecia) discharge large quantities of spores. Some of these spores are carried by the wind or by scattering drops of rain to the new foliage, where they produce the first

FIG. 75.— *Cross section of sweet-cherry leaf through an apothecium of the fungus Coccomyces hiemalis, showing the saclike bodies (asci) with needle-shaped ascospores*

infections of the year and the characteristic diseased spots become apparent about seven to ten days later. According to Higgins (1914) the apothecial conidia produced in many cases in the old apothecium are also able to produce infection. The writer also has commonly observed these conidia in old apothecia.

Control

Bordeaux mixture or lime-sulfur solution may be used for the control of the disease. The former, while very effective (Fairchild, 1893), may cause burning of the foliage. This is especially true when the mixture is applied to plum foliage.

Lime-sulfur solution, 1 gallon to 50 gallons of water, is effective in controlling the yellow-leaf disease on cherries and plums. Care must be taken not to apply the solution at such a strength that it will cause burning of the foliage. The addition of 3 pounds of iron sulfate prevents the danger of burning and also increases the sticking quality of the solution, especially if it is applied with a gas spraying machine.

Spraying experiments for the control of the yellow-leaf disease have been conducted from time to time and the results obtained have been very satisfactory. In Table 1 are tabulated the results of an experiment conducted throughout the summer of 1911 on a small block of Tartarian cherries, which had been budded on mazzard stocks the previous season. Two rows were sprayed, respectively, with lime-sulfur solution 1–50, and commercial bordeaux mixture 5–5–50, on the following dates: May 28, June 10 and 24, July 14 and 30, August 12. At the time of the first application the trees were from ten to fourteen inches in height. Two rows were left unsprayed as checks, and the remaining two rows received one application of lime-sulfur 1–50 on June 24.

Previous to the spraying of June 24 very little infection had occurred, owing to the dry weather conditions. Continued heavy rains followed the spraying of June 24 and conditions were very favorable for abundant infection. The application just previous to this infection period was most effective in keeping the yellow-leaf disease in check. On August 24 the first fifty-three trees of one row in each plat were measured for caliper and the measurements are recorded in Table 1. For each caliper measurement the percentage is also recorded. The average height of sprayed trees was five feet; the unsprayed trees averaged about four and one-fourth to four and one-half feet in height. A comparison of the number of trees for each caliper in sprayed and unsprayed plats shows a considerable difference in favor of the sprayed trees. The failure of the com-

(1893) Fairchild, D. G. Experiments in preventing leaf diseases of nursery stock in western New York. Cherry leaf-blight. Journ. myc. 7 : 249–252.
(1914) Higgins, B. B. Contribution to the life history and physiology of Cylindrosporium on stone fruits. Amer. journ. bot. 1 : 145–173.

mercial bordeaux mixture to control the disease as well as the lime-sulfur solution was attributed to the poor sticking qualities of the mixture.

TABLE 1. A COMPARISON OF CALIPER MEASUREMENTS OF TREATED AND UNTREATED TARTARIAN CHERRY TREES FOR THE EXPERIMENT CONDUCTED IN 1911

		Caliper measurements in inches							
		3/8		1/2		9/16		5/8	
Material used	Total number of trees	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Commercial lime-sulfur 1–50, six sprayings, row 1	53	16	30.2	29	54.7	5	9.4	3	5.7
Commercial bordeaux mixture 5–5–50, six sprayings, row 3 . . .	53	19	35.8	28	52.8	4	7.5	2	3.8
Lime-sulfur 1–50, sprayed once, row 7	53	21	39.6	28	52.8	4	7.5	0	0
Untreated, row 5. . . .	53	33	62.3	20	37.7	0	0	0	0

In Table 2 are shown the results of an experiment conducted throughout the summer of 1912. Three rows of first-year Tartarian cherry trees were sprayed with lime-sulfur solution 1–50, on the following dates: June 4 and 23, July 8 and 22, August 5 and 20. Two rows were left unsprayed as checks.

The data collected on September 19, 1912, showed a considerable increase in caliper of sprayed trees over unsprayed trees. One row of sprayed trees and one of the check rows were selected for the measurements and the first one hundred and twenty-five trees in each row were calipered. The average height of sprayed trees was four and three-fourths feet; the unsprayed trees averaged four to four and one-fourth feet in height.

When the measurements were taken for the above experiments the unsprayed trees had lost practically all of their leaves. For nurserymen

TABLE 2. A COMPARISON OF CALIPER MEASUREMENTS OF TREATED AND UNTREATED TARTARIAN CHERRY TREES FOR THE EXPERIMENT CONDUCTED IN 1912

Material used	Total number of trees	Caliper measurements in inches																					
		1/4		3/8		7/16		1/2		9/16		5/8		11/16		3/4		13/16		7/8		15/16	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Lime-sulfur 1–50.....	125	0	0	5	4.0	4	3.2	11	8.8	24	19.2	32	25.6	31	24.8	9	7.2	6	4.8	2	1.6	1	0.8
Untreated.....	125	3	2.4	15	12.0	16	12.8	25	20.0	38	30.4	11	8.8	17	13.6	0	0	0	0	0	0	0	0

the increase in size of stock is certainly an important factor, but the effect of premature defoliation in unsprayed trees is also worthy of consideration. The early loss of foliage prevents proper maturation of the wood, and the trees are less likely to withstand the severe weather of winter. Winter injury occurs commonly on cherry and plum stock, and several cases have been observed in which the indications are that early defoliation in the previous summer favored the injury that occurred during the cold months.

It has been the custom of some growers to hold the shipment of mazzard seedlings, when received from Europe, in storage until late in the spring, after all the other seedling stock has been planted. If this method is followed the development of the seedlings when finally planted is very rapid, and they are more likely to make a sufficient growth for budding before they succumb to the attacks of the yellow-leaf disease. Certain nurserymen have suffered considerable loss due to injury of mazzard seedlings while in storage, however, and in general this means of warding off the disease does not seem to be practicable. The writer has conducted several experiments with reference to this question, and is led to conclude that the disease can be prevented more profitably by spraying. It is better to plant the mazzard stock when the other seedlings are put into the ground, and to prevent the early attacks of the yellow-leaf fungus by spraying. The first application should be made soon after the leaf buds open, and should be followed by at least four or five additional sprayings at intervals of from ten to fourteen days.

For the first-year buds the first application should be made when the buds are from eight to twelve inches in height. Subsequent sprayings should be in accordance with the weather conditions that exist. As a general practice, about five to seven applications throughout the summer, at intervals of two weeks, will suffice to keep the disease in check.

As a general recommendation for all stock susceptible to the yellow-leaf disease, the spray should be applied at such intervals as to keep as much of the new growth protected as is possible.

POWDERY MILDEW OF CHERRY

Powdery mildew of cherry is practically the same as the mildew that attacks apple stock, and according to Hein (1908) is occasionally found on plum, hawthorn, Spiræa, blueberry, and persimmon. In the nurseries of New York State the budded sour-cherry stock is usually most severely attacked, but often the disease is destructive on the sweet-cherry varieties and the mazzard stocks.

(1908) Hein, W. H. Two prevalent cherry diseases. Powdery mildew. Nebraska Insect Pest and Plant Disease Bureau, Bot. Div. Circ. 2 : 1–2.

The young, succulent leaves are particularly susceptible to the disease, and following a period of heavy rainfall a serious epiphytotic may occur.

Symptoms

The disease can generally be recognized by the characteristic upward rolling of the foliage, accompanied by a shortening and an increased thickness of the internodes of the twigs (Fig. 76). The young shoots, the tips of the branches, and the leaves are affected. The curled leaves are covered on the undersurface with a tangle of white, feltlike threads. Usually after midsummer, when the disease is well established and the leaves are severely infested, small black specks may be observed scattered on the surface of the feltlike mass on the underside of the leaf.

Fig. 76.—*Mildew on sour-cherry twigs: healthy twig on the left, diseased twig on the right. Showing the curled leaves, a shortening of the internodes, and an increased thickness of the twig*

The disease is caused by the fungous parasite, *Podosphæra oxyacanthæ* (DC.) de Bary. The same fungus may attack the apple also. The thick network of fungous threads form the white patches on the surface of the host tissue. From these mycelial threads stalks are sent up (Fig. 94, page 225), which bear the conidia. The conidia are produced in great abundance, and, being carried by wind and rain to healthy foliage, they serve to spread the parasite throughout the summer.

The fungus is bridged over the winter by means of the sexual stage (perithecia, Fig. 70, page 183), which appears on the white mycelium in late summer as the small black specks previously discussed. The perithecium contains an ascus with eight spores, and in the spring or early summer these spores are discharged. Lodging in a suitable place, such as on the surface

of a cherry leaf, the ascospores germinate by a germ tube and produce the first infections of the summer. Summer conidia are soon developed and new infections follow.

Control

Bordeaux mixture has been recommended by certain investigators for the control of this disease, but it is believed that better results are to be obtained with certain sulfur compounds. Dusting with dry powdered sulfur (flowers of sulfur) is also claimed by some to be effective; however, no satisfactory data are at hand to substantiate this claim.

The writer has obtained good control by the use of lime-sulfur solution diluted 1 to 50. The addition of 3 pounds of iron sulfate to 50 gallons of the mixture tends to reduce the possibility of injury to the foliage and also increases the sticking quality of the mixture.

The first application should be made as soon as the disease appears (Ballard and Volck, 1914), which for the nurseries of New York State is usually about the latter part of June. The appearance and prevalence of the disease varies, depending on weather conditions. From three to five sprayings may be necessary in order to keep the mildew in check. As a rule the sprayings for the yellow-leaf disease of cherry and plum, caused by the Cylindrosporium fungus, are sufficient for the control of the mildew also.

ANTHRACNOSE OF CURRANTS AND GOOSEBERRIES

The leaf disease commonly known as anthracnose, leaf blight, or leaf spot, is of considerable importance in nursery stock and often causes heavy defoliation of the stock in early summer. The disease is widely distributed and is known to occur in Europe, America, Asia, and Australia. In 1873 it was first reported in America as affecting black currants. Since that time it has been reported from various sections of the country, as affecting the cultivated varieties of currants and gooseberries. The disease is doubtless found in all sections of the United States where currants and gooseberries are grown.

Occurrence on different hosts

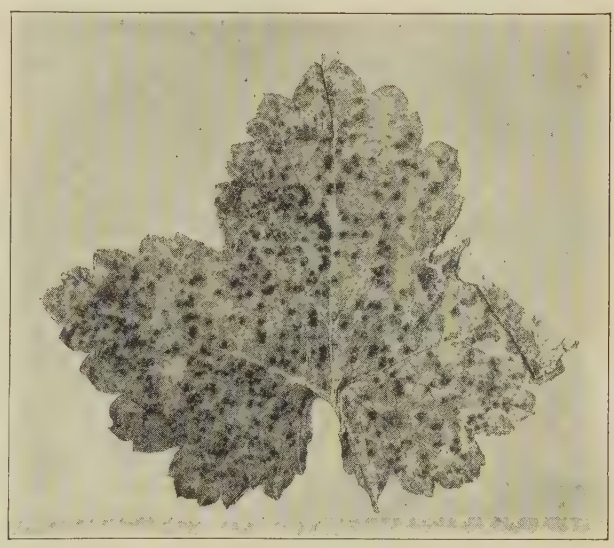
Anthracnose has been reported on several species of currants — including *Ribes nigrum*, *R. acicularis*, *R. aureum*, *R. prostratum*, and *R. rubrum* — and on gooseberries, *R. reclinatum* and *R. oxyacanthoides*. Black currants (*R. nigrum* and *R. aureum*) are usually more or less resistant and are seldom severely affected. Some differences are to be noted in the susceptibility of the varieties of red and white currants, though all may

(1914) Ballard, W. S., and Volck, W. H. Apple powdery mildew and its control in the Pajaro Valley. U. S. Agr. Dept. Bul. 120 : 1–26.

succumb to the disease. Stewart and Eustace (1901) found the Albert variety practically free from the disease when Fay and Victoria adjoining them were seriously affected. Observations made by the writer on August 4, 1914, in a large block of nursery stock, showed the following varieties completely defoliated: White Grape, Fay, Victoria, Wilder. The varieties Moore Ruby and Perfection were not so seriously affected. On September 1 very little foliage remained on any of the varieties.

As a rule, gooseberries are more resistant. The varieties Smith, Industry, and Whitesmith are more susceptible than the varieties Downing and Pearl. The Houghton variety is often severely affected.

Older bushes often suffer more than do first-year cuttings, a condition commonly observed in the nursery. The fact that the cuttings are usually planted on ground that has not been used for currant and gooseberry stock for some time and is perhaps some distance from the older plantings, no doubt accounts for the apparent resistance of the cuttings. Where cuttings have been planted in close proximity to old diseased bushes, they have been known to become diseased.



PHOTOGRAPH BY F. C. STEWART

Fig. 77.— *A leaf of red currant affected with anthracnose*

Symptoms

The disease first appears on the older leaves, which become covered on the upper surface with small, circular spots, dark brown in color and about one twenty-fifth of an inch in diameter. In the center of each spot there is developed a minute black area (Fig. 77). Soon the foliage turns yellow and diseased bushes may be recognized for a considerable distance. The petioles, flower stalks, young canes, and berries are affected; the black and slightly sunken spots on the petioles are readily

(1901) Stewart, F. C., and Eustace, H. J. An epidemic of currant anthracnose. New York (Geneva) Agr. Exp. Sta. Bul. 199 : 63–80.

noticeable. The spots on the fruit stems may be one-half inch or so in length and extend half the distance around the stem. The pustules on the canes have never been found on wood more than one year old. Small black specks characterize the disease on the fruit; it is especially noticeable when the fruit of gooseberry bushes is affected.

The anthracnose disease is very often associated with the Septoria leaf spot, but the two diseases are readily distinguishable. The Septoria lesions (Fig. 79, page 199) appear dead and brown, and are larger, being one-eighth of an inch or more in diameter. On close examination very minute black specks are seen in the center of the Septoria spots.

Cause

The disease is caused by the fungus *Pseudopeziza ribis* Kleb. (Klebahn, 1906). The parasitic stage is known as *Glœosporium ribis* (Lib.) Mont. et Desm.

Life history

The fungus is propagated throughout the growing season by means of summer conidia which are produced in a fruiting body known as an acervulus (Fig. 78). The acervulus develops within the affected area of the host tissue, and when mature breaks through the epidermis, liberating the conidia, which are pushed out in a gelatinous mass. During a rain period the gelatinous substance is dissolved and the conidia are disseminated by wind and rain. Falling on the leaves, new infections are produced when the weather conditions are such as to afford moisture for the germination of the conidia. The conidia send out germ tubes which penetrate the leaves. Within the host tissue the germ tubes continue to develop, forming a mycelium which kills the cells, resulting in the appearance of the characteristic lesions of the disease from ten to fourteen days later.

FIG. 78.— *Cross section of affected part of currant leaf, through an acervulus of the anthracnose fungus. The epidermal cells of the leaf are pushed up and the spores of the fungus are escaping*

The conidia that are produced late in the season may live throughout the dormant season and bridge the fungus over winter, but in many cases a specialized fruiting body (apothecium) is developed in the diseased leaves that fall to the ground in the autumn. In the following spring ascospores are developed in the apothecium, and usually soon after the first leaves are pushed forth on the bushes the ascospores are discharged.

(1906) Klebahn, H. Untersuchungen über einige fungi imperfecti und die zugehörigen ascomycetenformen. III. Gloeosporium ribis (Lib.) Mont. et Desm. Zeitschr. pflanzenkr. **16** : 65-83.

Carried by wind and rain they fall on the new foliage and germinate, thus producing the first infections of the season.

The fungus is apparently influenced by the same weather conditions as the other fungi causing leaf diseases. With a heavy precipitation followed by damp, cloudy weather, the disease becomes more severe. Several epiphytotics of the disease have been observed in the nursery which could be associated with a previous infection period of that nature.

Control

The suggestions of Stewart and Eustace (1901) for the control of the anthracnose disease with bordeaux mixture proved fairly satisfactory, and later Ewert (1907) found that plants sprayed with one-per-cent bordeaux mixture showed very little infection while adjacent plants were badly diseased. The applications made at intervals of from ten to fourteen days after May 1 were effective in checking the disease. Sprayings made before the first of May were of no value.

Throughout the season of 1912 an experiment for the control of the disease on Fay currants was conducted by the writer in one of the large nurseries of New York State. Three rows were sprayed with lime-sulfur 1–40, and three other rows with bordeaux mixture 5–5–50; the remaining ten rows in the block served as checks. The applications were made on the following dates: May 5 and 20, June 6 and 22, July 8, and August 4. By August 10 the unsprayed bushes were completely defoliated, while those that had been sprayed were practically free from disease and held their foliage until digging time.

A similar experiment was conducted on White Grape currant nursery stock (two-years-old bushes) in 1914, but only lime-sulfur 1–50 was used. Sprayings were made on May 8 and 21, June 5 and 30, July 25, and August 10. Frequent rains during July and August caused abundant infections and the unsprayed plants had lost their foliage by August 4. The sprayed bushes showed but little disease and held their leaves until digging time.

When applied at the proper time, bordeaux mixture 5–5–50, or lime-sulfur 1–40 or 1–50, is effective in controlling the disease. It is advisable to make the first application about the time when the leaves are unfolding, and other applications at intervals of from ten to twenty days until about five or six sprayings have been made. It is essential to keep the foliage covered and well protected throughout the summer. In a dry season so many sprayings may not be required, while on the other hand prolonged

(1901) Stewart, F. C., and Eustace, H. J. An epidemic of currant anthracnose. New York (Geneva) Agr. Exp. Sta. Bul. 199 : 63–80.

(1907) Ewert, R. Ein beitrag zur entwickelungsgeschichte sowie zur ermittelung der infektionsbedingungen und der besten bekämpfungsart von Glœosporium ribis (Lib.) Mont. et Desm. (Pseudopeziza ribis Kleb.) Zeitschr. pflanzenkr. 17 : 158–169.

wet weather necessitates more frequent applications. For the first two sprayings it is usually desirable to add 2 pounds of arsenate of lead to 50 gallons of the solution as a preventive against the attacks of worms.

SEPTORIA LEAF-SPOT OF CURRANTS AND GOOSEBERRIES

The Septoria leaf-spot (Pammel, 1891, 1892) occurs on various species of Ribes. In New York State it is often the chief cause of the dropping of currant leaves and may also be destructive on gooseberries; this is especially true for nursery stock. In the spring of 1913 this disease was exceedingly prevalent in several large nurseries that were visited by the writer, and heavy defoliation resulted during the month of June. In many cases the disease may be found on the same leaves that are affected by anthracnose.

All the stand rd varieties of currants and gooseberries grown in New York State may be affected, but some are more resistant than others. The white and red currants are more susceptible than the black varieties, such as Naples. It is to be noted, however, that the Septoria leaf-spot is usually more severe on the black varieties than the anthracnose disease previously discussed. Usually when affected by the leaf-spot the foliage of the white and red currants falls more readily than that of *Ribes nigrum*, variety Naples.

Symptoms

The Septoria leaf-spot disease causes rather large lesions with grayish centers and brown borders. Usually the spots are about one-eighth of an inch in diameter and are more or less angular in outline. Within the grayish center of old lesions may be observed several minute black specks (Fig. 79). The spots may be few or many on the leaf; when they are numerous, the leaf turns yellow and falls readily. The Septoria leaf-spot may be easily distinguished from the anthracnose disease (Fig. 77) by the much larger and well defined lesions, with characteristic light-colored centers. It has been reported by Stewart and Eustace (1901) that the Septoria spots on foliage of *Ribes nigrum* may be considerably smaller than the usual size found on red and white varieties, but in every case the spots are always larger than those of the anthracnose. The anthracnose lesions are black and often are no larger than a pinhead.

Cause

The disease is caused by the fungus *Septoria ribis* Desm., and is very similar to the fungus causing the Septoria leaf-spot of pears (Fig. 91, page 218).

(1891) Pammel, L. H. Spot diseases of currants and gooseberries. Iowa Agr. Exp. Sta. Bul. 13 : 67–70.
(1892) Pammel, L. H. Treatment of some fungus diseases. Currants. Iowa Agr. Exp. Sta. Bul. 17 : 420–421.
(1901) Stewart, F. C., and Eustace, H. J. An epidemic of currant anthracnose. New York (Geneva) Agr. Exp. Sta. Bul. 199 : 67.

Life history

When the fruiting bodies (pycnidia) of the fungus in the old spots on the leaves are mature, the spores are pushed out through the opening in the top of the pycnidium. Carried by wind and rain, they are disseminated in all directions. Falling on newly developed leaves, the spores germinate by germ tubes when moisture conditions are suitable. The germ tube penetrates the host cells and develops a mycelium within

PHOTOGRAPH BY F. C. STEWART

FIG. 79.—*A leaf of red currant affected by the leaf-spot fungus, Septoria ribis*

the leaf tissue, thus producing a new infection. The lesion becomes apparent some days later, and with the development of the fungus the spot assumes the characteristic appearance with the minute black pycnidia in the pale central dead area. Soon mature spores are pushed out of the pycnidia and a means for further spread of the fungus is afforded. The pathogen continues to spread throughout the summer whenever weather conditions are favorable. As with practically all leaf-spot fungi heavy rains, followed by damp, cloudy weather, greatly augment the spread of this parasite.

Although not definitely determined, it is very probable that the fungus lives over winter by a sexual stage on the fallen currant and gooseberry leaves. In spring the production of spores by the sexual stage, and their dissemination to the newly developed foliage of species of Ribes, probably account for the first infections of the season.

Control

Sprayings that are suitable for the control of the anthracnose control also the Septoria leaf-spot. The first application should be made soon after the new leaves are pushed forth in the spring. This spraying should be followed by two or three applications made at intervals of from two to three weeks. Bordeaux mixture, or lime-sulfur 1–50, is very effective in the control of this disease. Lime-sulfur at a strength of 1–40 also has been used on currant and gooseberry foliage without causing any burning of the leaves.

The spraying should be thoroughly done, in order to cover all the leaves. Owing to the bushy growth, some difficulty is often experienced in properly spraying the foliage on the larger currant and gooseberry stock. Care should be taken to coat all the leaves with the fungicide.

THE GOOSEBERRY MILDEW

The gooseberry mildew is often very destructive and is of considerable economic importance. It occurs in all parts of America where gooseberries are grown and is known to occasionally affect currant bushes also.

Apparently the disease was confined to America until about 1900, when it was reported from Europe (Salmon, 1905), and in 1906 a serious outbreak of the gooseberry mildew occurred there. Since that time it has appeared there every year and according to Eriksson (1915) it has been very destructive. The European varieties of gooseberries are not able to withstand the attacks of the mildew and for that reason the spread of the disease has been exceedingly rapid. In America the varieties of gooseberries imported from Europe are more susceptible to the mildew than the varieties that have originated in this country. The Smith and Whitesmith varieties are less resistant than the Downing. The Houghton is the most susceptible of the American varieties. Although the disease is widespread there is a tendency for it to be localized in certain plantings, where it becomes established and appears to some extent each year. This condition is particularly noticeable in nursery stools, which remain on the same ground for a period of years. The mildew first appears on these stock plants and later spreads to other plantings if conditions

(1905) Salmon, E. S. On the present aspect of the epidemic of the American gooseberry-mildew in Europe. Journ. Roy. Hort. Soc. **29** : 102–110.
(1915) Eriksson, Jakob. International phytopathologic collaboration. Phytopath. **5** : 133–140.

are favorable. This disease is more destructive during wet seasons, and may flourish so abundantly that it is very difficult to control. The lower parts of the bushes, which are more or less shaded, are usually first affected.

Symptoms

The leaves, the stems, and the fruit are attacked. The first appearance of the disease is usually in May or June. Small white patches may be noticed on the fruit, usually on the lower parts of the bush where there is considerable shade. The spots on the fruit continue to enlarge, becoming somewhat darker in color, and the feltlike blotches may practically cover the fruit. If the disease is severe the fruit may be stunted in its development and may even decay somewhat.

In the nursery the mildew is commonly observed on the tips of the young shoots in June or the early part of July. The white, feltlike spots continue to enlarge and may almost completely cover the tips, extending for some distance down the shoots. If the disease is very severe the new growth is destroyed and the older wood may be considerably injured. The writer has observed second-year nursery plantings in which the foliage was almost entirely killed by the mildew during July and August. This condition not only checks the development of the stock for the season, but also makes the bushes more susceptible to winter injury.

In commercial plantings the disease is often so severe as to destroy the crop of fruit and to seriously damage the bushes.

Cause

The gooseberry mildew is caused by the parasitic fungus, *Sphærotheca mors-uvæ* (Schw.) B. & C. This fungus is very similar to the organism causing the mildew on roses (Fig. 94, page 225), and resembles in many respects the mildew of apples (Fig. 70, page 183).

Dense masses of mycelial threads of the fungus form the white patches on fruit and twigs. Certain mycelial threads are pushed up, and on these are borne large numbers of conidia.

Life history

The conidia borne in the white patches of mycelium serve to spread the fungus throughout the summer. Carried by wind and rain, a conidium falling on a gooseberry leaf germinates, if sufficient moisture is present, and produces a mycelium, which is apparent to the naked eye a few days later. With the development of the mycelium, resulting in the formation of the characteristic mildew spots, conidia are produced, which are a means of further spreading of the parasite. After midsummer specialized fruiting bodies (perithecia) are produced in the old mycelial patches of mildew on

the twigs, and these fruiting bodies, being very resistant to cold and adverse conditions, bridge the fungus over winter. In spring or early summer the perithecia discharge mature ascospores, which are carried by wind and rain and produce the first infection on the new foliage. On these infected areas conidia are developed which propagate the fungus throughout the summer.

Control

As in the case of most mildew diseases, bordeaux mixture has not proved effective in controlling the gooseberry mildew. The mycelium of this fungus is more persistent than that of most mildews, and the disease is somewhat more difficult to control. Close (1899) conducted some rather extensive experiments for the prevention of this disease, and found that potassium sulfide, 1 ounce to 2 gallons of water, was much more effective than the other mixtures tested — bordeaux mixture, lysol, and formalin. He recommends that the first spraying with potassium sulfide be made just as the buds are opening, and if the conditions are such that the disease threatens to be serious the sprayings should be continued at intervals of from ten to fourteen days.

Lime-sulfur solution 1–40 is also effective for the control of this disease. The first spraying should be made early in the season as soon as the mildew appears, and subsequent applications should be made according to the prevalence of the disease; if very abundant three or four sprayings at intervals of from eight to twelve days may be necessary in order to protect the developing shoots.

LEAF-BLOTCH OF HORSE-CHESTNUT

Leaf-blotch, also known as leaf-blight, is undoubtedly the most destructive disease affecting the horse-chestnut. This is particularly true of nursery stock. Very often the seedling beds are completely defoliated by midsummer and the growth of the young trees is greatly retarded.

When the disease has become established in a block of trees, it usually causes considerable damage each year. The affected trees develop more slowly and a longer period of time is required for them to attain a marketable size. The writer has observed certain blocks of horse-chestnuts which were so severely affected that they made practically no growth throughout the summer. Trees imported from Europe and transplanted to the nursery are sometimes not so severely injured, especially the first year. This is probably due to the fact that the trees are frequently set out at a considerable distance from other horse-chestnut plantings, and the disease does not become established in the newly planted trees the first season.

(1899) Close, C. P. Treatment for gooseberry mildew. New York (Geneva) Agr. Exp. Sta Bul. 161 : 153–164.

The leaf-blotch disease is widely distributed and occurs in practically all countries where the horse-chestnut grows. It is very common in New York State on forest and shade trees as well as on nursery stock.

Symptoms

The leaves, and occasionally the petioles, are affected. The first indication of the disease on the leaf is a slight discoloration on the upper side, resulting in the formation of a small yellowish or red spot, about one millimeter in diameter. After three or four days, as the disease extends into the healthy tissue from the point of infection, the lesion appears water-soaked. Gradually the center of the lesion becomes dark red to brown in color, while the margin shows the yellowish discoloration, blending into the green of the healthy tissue; and finally the discolored area becomes dried out and dead. The spots are somewhat irregular in shape; they may be small or of considerable size, involving a large part of the leaf and causing the dead area to curl (Fig. 80). Clusters of minute black specks may be noticed occasionally in the diseased area.

FIG. 80.— *Leaf of a horse-chestnut seedling affected with the leaf-blotch disease. Some of the leaflets are slightly curled and distorted*

The disease appears on the petioles as irregular dark brown areas. Usually the lesions extend up and down the petiole, and they may be somewhat longer than wide.

Cause

The disease is caused by the fungus *Læstadia æsculi* Peck, of which the conidial and parasitic form is known as *Phyllosticta paviæ* Desm.[2]

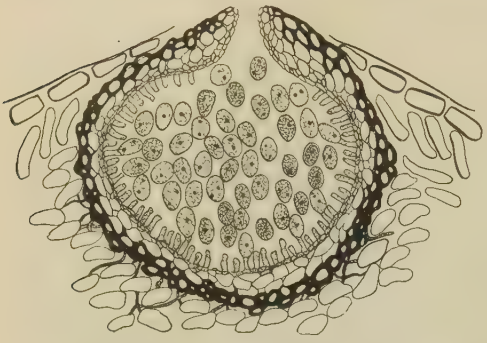


FIG. 81.— *Cross section of horse-chestnut leaf through a pycnidium of the fungus, showing the spores inside, which escape through the opening in the top of the pycnidium*

Life history

In certain areas of the older lesions, numerous fruiting bodies (pycnidia, Fig. 81) may be noticed, appearing as small black specks. When these are mature, spores are discharged from them and disseminated by wind and rain. Falling in a suitable place, such as on a horse-chestnut leaf, the spore germinates in the presence of moisture and produces a new infection, which is apparent in from about eight to twelve days. In this lesion new pycnidia are produced which discharge mature spores, and in this way the fungus continues to spread throughout the summer. The fungus lives over winter by means of the sexual stage (perithecia, Fig. 82), which develops on the fallen leaves. In early spring ascospores are discharged from the perithecia in the old leaves, and if they fall on the newly developed foliage, with conditions suitable for their germination, they produce the first infections of the season. From these infections the pycnidia are produced and the fungus is spread further throughout the summer.

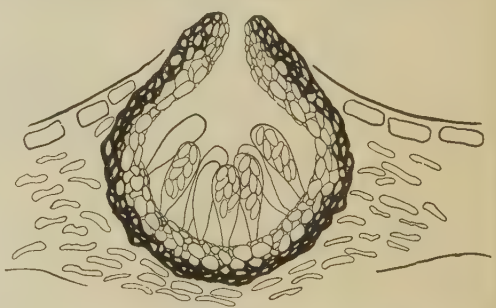


FIG. 82.— *Cross section of horse-chestnut leaf through a perithecium, showing the saclike bodies (asci) with ascospores. In early spring the spores are discharged from the asci and escape through the opening in the top of the perithecium*

[2]In May, 1885, G. W. Clinton collected this fungus near Albany on the petioles of *Æsculus hippocastanum*, and it was described by C. M. Peck (Report of New York State Botanist **39**: 51. 1885) as a new species. He gave it the name *Læstadia æsculia*. In May, 1914, the writer collected fallen horse-chestnut leaves which showed a similar fungus, and a similar organism was observed also on horse-chestnut leaves which were affected with the leaf-blotch in the fall of 1913 and had been exposed to the weather throughout the winter months in a wire screen. Inoculations with ascospores, resulting in the production of the characteristic Phyllosticta lesions, show that the fungus on the over-wintered leaves is the sexual stage of *Phyllosticta paviæ*. Morphological studies led the writer to believe that the fungus named by Dr. Peck as *Læstadia æsculi* Peck and the fungus on the wintered leaves are identical. It is of interest also to note in this connection that a spermogonial stage has been observed in the life cycle of the leaf-blotch fungus. A more complete discussion of this question is to follow in a subsequent publication.

Control

But little experimental work has been done in the control of this disease. Fairchild (1894) conducted some experiments for the prevention of the leaf-blotch in the nursery and obtained fairly satisfactory results with the use of bordeaux mixture. The sprayed seedling trees made a better growth, and also held their foliage longer, than the untreated trees. Fairchild was of the opinion that better results would have been obtained if the applications of the fungicide had been more numerous. Several attempts have been made by the writer to check this disease in the nursery, but the results were not satisfactory. The disease has always been found to a large extent on the treated trees. It is believed, however, that the sprayings were not started early enough. Studies of the life history of the fungus indicate that the first infection may occur soon after the new leaves push forth. In order to prevent the fungus from becoming established, therefore, it is necessary to spray before these first infections occur in early spring.

Lime-sulfur solution 1–40, also lime-sulfur plus iron sulfate, 3 pounds to 50 gallons, and bordeaux mixture, were used in the experimental work for the control of this disease. The sprayed trees showed less disease than did the untreated stock. Commercial bordeaux mixture did not stick so well to the smooth foliage of the horse-chestnut as did the lime-sulfur solution.

It is recommended that the first spraying for the prevention of this disease be made just after the leaf buds burst in the spring. This application should be followed by at least two other sprayings, made at intervals of from ten to fourteen days. Two or three additional applications are usually advisable. The time for these later sprayings should be governed by weather conditions; in rainy seasons the applications need to be made more frequently in order to keep the foliage covered and protected.

PEACH LEAF-CURL

Peach leaf-curl is distinctly pecular to the peach and to forms derived from it, such as the nectarine and the peach almond. The peach is the natural host for the leaf-curl parasite, but the disease has been observed, though rarely, on plums and almonds also.

Leaf-curl is now a more or less common disease in all regions where peaches are grown. It has been known for a long time in England, where it was described as early as 1821, by an English gardener, as " blister." According to Pierce (1900), it is usually severest near the seacoast or large

(1894) Fairchild, D. G. Experiments with fungicides to prevent leaf-blight of nursery stock. Horse-chestnut leaf-blight (*Phyllosticta sphæropsoidea* E. & E.) Journ. myc. 7: 352–353.

(1900) Pierce, N. B. Peach leaf curl: its nature and treatment. U.S. Agr. Dept., Veg. Path. and Phys. Div. Bul. 20: 1–204.

interior lakes. It is very common and destructive in the peach-growing section of the United States and Canada, about the Great Lakes.

Pierce (1900) has estimated that the annual loss caused by this disease in the orchards of the United States is $3,000,000. In the nursery the loss is particularly noticeable from the fact that the young trees are affected when they are in the most critical stage of their development, namely, just as the grafted buds start to grow in the spring. Peach leaf-curl was epiphytotic in the nurseries of New York State in 1909 and also in 1910. Careful observations as to the damage caused by this disease showed that about eighty-five per cent of the infected shoots failed to develop into first-class trees. The following is taken from notes made by the writer on July 16, 1910, with reference to the leaf-curl disease in one of the large nurseries of this State.

"A severe windstorm blew over many peach trees (first-year buds). In most cases the trunks of these trees were affected with the peach leaf-curl disease. Weekly measurements have been made of about two hundred and twenty trees since May 30. The average height of the healthy stock on July 8 was 34 inches, as compared with 14 inches for the average height of the diseased stock. Out of sixty-eight diseased trees ten are first-class stock, fifty can never be put on the market, and it is doubtful whether four are salable. Out of fifty-six healthy trees recorded, fifty-four are first-class stock."

Varietal susceptibility

Different varieties grown under similar conditions show marked differences in susceptibility to the disease. A comparison of data on varietal resistance of trees in different regions may show some conflicting statements as to the resistance of certain varieties. This, no doubt, is due to the fact that the same variety is known to show marked difference in its resistance to leaf-curl when grown under diverse environmental conditions (Duggar, 1899).

In 1909 and 1910, when peach leaf-curl was very abundant in the nurseries of New York State, accurate counts were obtained as to the susceptibility of the different varieties. In Table 3 are listed the different varieties, the total number of trees of each variety, and the number and percentage of trees that were so badly diseased as to be unsalable. It is to be considered that the number of trees affected greatly exceeds the number included in this table, which gives only the number of trees that were ruined. Some shoots having only one or two leaves affected outgrew the disease, and the trees developed sufficiently to be marketable.

(1899) Duggar, B. M. Peach leaf curl. New York (Cornell) Agr. Exp. Sta. Bul. 164 : 371–388.
(1900) Pierce, N. B. Peach leaf curl: its nature and treatment. U. S. Agr. Dept., Veg. Path. and Phys. Div. Bul. 20 : 1-204.

A comparison of the percentage of diseased trees of the varieties Carman and Richards is of interest. These two varieties were grown in the same block, under similar conditions, and received the same amount of cultivation and attention throughout the season.

TABLE 3. A COMPARISON OF THE SUSCEPTIBILITY OF DIFFERENT VARIETIES OF PEACH TREES TO THE LEAF-CURL DISEASE

Variety	Total number of trees	Number of unsalable trees	Percentage of unsalable trees
Carman	4,185	1,076	25.7
Elberta	4,375	903	20.6
Oldmixon Free	2,812	390	13.9
Triumph	2,120	273	12.9
Mountain Rose	431	49	11.4
Late Crawford	2,838	300	10.6
Globe	1,953	169	8.6
Heath	851	42	4.9
Champion	3,130	132	4.2
Crosby	2,279	86	3.8
Smock	1,899	44	2.3
Wheatland	636	12	1.9
Stump	1,448	24	1.6
Willet	308	5	1.6
Wager	686	11	1.6
Chairs	680	10	1.5
Niagara	681	9	1.3
Chili	378	5	1.3
Morris White	684	9	1.3
Salway	582	5	.8
Sneed	273	2	.7
Fitzgerald	2,086	9	.4
Greensboro	725	3	.4
Early Canada	639	2	.3
Foster	530	1	.19
Richards	2,398	1	.04

Symptoms

The first evidence of the disease is the arching and reddening of the affected areas in the young unfolded leaves as they begin to protrude from the opening bud scales. The lesions may be confined to a part of the blade or the petiole, or they may involve the entire leaf and extend into the twig. The diseased parts are thick and brittle, causing a considerable increase in weight of the affected leaves. With the maturation of the leaves the pale yellow or red color disappears and the hypertrophied area on the upper surface becomes silvery in appearance. The first leaves to expand are usually the most affected, and the curled leaves finally die and drop from the tree. A new crop of leaves may be developed on orchard trees following the defoliation, and these are seldom affected.

PHOTOGRAPH BY WALLACE AND WHETZEL

FIG. 83.— *A peach bud, showing the effects of the leaf-curl disease on leaves and stem*

The flowers and the young fruit of orchard trees may also be attacked, according to Wallace and Whetzel (1910), and on the rapidly growing shoots the disease causes a marked swelling, checking their growth in length and causing a marked increase in diameter.

The sickly, yellow, curled foliage and the distorted shoots of the young buds (Fig. 83) are the striking characters of this disease in the nursery. Also, the badly affected trees are considerably shorter than the healthy stock (Fig. 84).

Cause

The disease is caused by an ascomycetous fungus known as *Exoascus deformans* (Berk.) Fckl. On the surface of old affected tissues the fungus

FIG. 84.— *Carman peach buds. The trees on the left were affected with leaf-curl early in the season and made a stunted growth as compared with the healthy trees shown on the right. Photograph made on July 15, 1910*

develops minute saclike bodies, known as asci (Fig. 85). These contain spores which are discharged and serve as a means of disseminating the fungus.

Life history

The complete life history of the parasite is as yet unknown. Although not definitely determined, it is presumed that spores of some kind which propagate the fungus are lodged by wind or rain among the hairs of bud scales of the host plant in spring, and remain dormant over winter until favorable conditions arise in the following year.[3] In spring the

(1910) Wallace, Errett, and Whetzel, H. H. Peach leaf curl. New York (Cornell) Agr. Exp. Sta. Bul. 276 : 157–178.

[3] The question arises as to the use of scions cut from trees on which there is considerable leaf curl. In the year 1910, when there was a very large amount of curl in one of the large nurseries of the State, all the scions for budding were cut from blocks in which there were many affected trees. In the following year conditions were unfavorable for the disease, and only one diseased bud was observed out of the 300,000 trees examined.

spores germinate during rains, which cause the buds to swell; and the germ tube, passing in between the loosened bud scales, penetrates and establishes the parasite within the young leaf tissues. It was at one time believed that the mycelium of the fungus was perennial, wintering in the diseased twigs, growing out into the leaves, and developing shoots in the spring; but according to Pierce (1900) it is very doubtful whether infections arise in the early spring from a perennial mycelium.

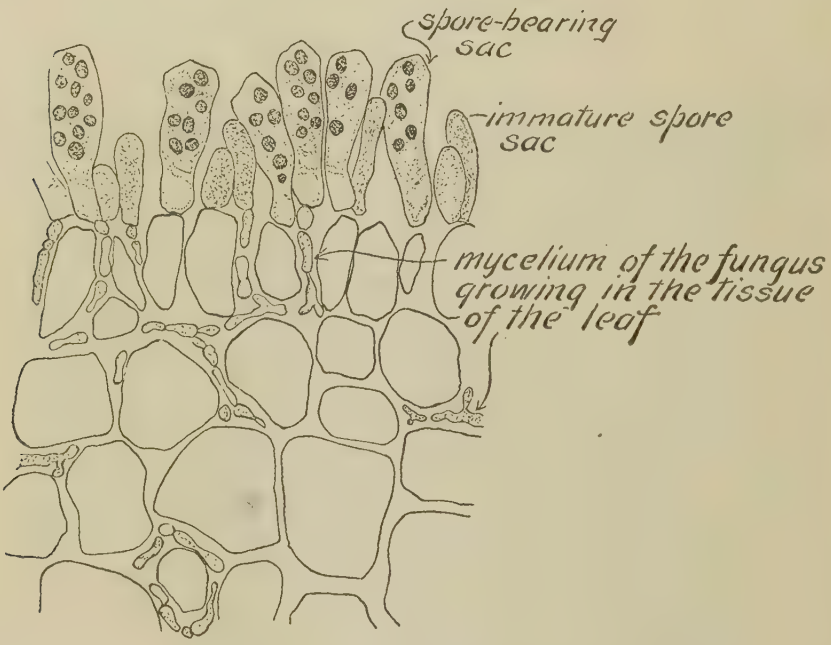


FIG. 85.— *Cross section of a diseased part of a peach leaf, showing the fungus and its relation to the leaf tissue. After Wallace and Whetzel*

Control

Bordeaux mixture or lime-sulfur 1–20 is very effective in the control of this disease. Only one spraying is necessary, but it is essential that this application be made before growth starts in the spring and the buds have started to swell. Thoroughness of the application is of absolute importance. Every bud must be completely coated with the fungicide.

For New York nurserymen, spraying each year for peach leaf-curl is considered advisable as an insurance against the disease. The spraying should be done as soon as the peach stocks are "snagged" and before

(1900) Pierce, N. B. Peach leaf-curl: its nature and treatment. U. S. Agr. Dept., Veg. Path. and Phys. Div. Bul. 20 : 1–204.

the rush of spring work begins. If it is desired to control San José scale also, an application of lime-sulfur solution 1–9 will control both the scale and the leaf-curl disease. It is absolutely essential that the grafted bud in the stock be thoroughly coated with the spray mixture. The thoroughness of the spraying depends on several factors: (1) When budding is done late some nurserymen fail to cut the strings. Many of these old strings do not rot and fall off the stocks, and in spring these may partially cover the bud, thus preventing the fungicide from completely covering the bud. (2) Plowing up to the stocks in autumn and the upheaval of the ground by frost frequently leave the bud covered with dirt at the time for spraying. (3) The most important factor is a satisfactory means of applying the fungicide. A power sprayer can be used with trailers, one man spraying each row. However, very satisfactory results have been obtained by the writer with the use of hand sprayers having an extension rod (Fig. 86). Such an outfit insures that the bud will be reached by the spray mixture and thoroughly covered. Lime-sulfur solution is preferable for leaf-curl spraying, as the application can be combined with the spraying for San José scale, which is done while the trees are still dormant.

PHOTOGRAPH BY D. GUNN

FIG. 86. — *Compressed-air hand sprayer, with extension rod and nozzle attached*

Although the natural buds on the stocks are also attacked, no damage occurs from these infections as the natural buds are sprouted soon after growth begins. In some seasons there may be considerable infection in the natural buds while the grafted bud-shoots remain free from disease. This condition is doubtless due to the fact that the natural buds start growth a few days earlier than the grafted buds. With conditions favorable for infection when the natural buds started to develop, the failure of the grafted buds to become diseased some days later can be attributed to changes in the weather, particularly a rise in temperature.

From the information at hand it may be generally stated that the peach leaf-curl disease is of considerable economic importance, both to the orchardist and to the nurseryman. It is the usual practice of the orchardist

to spray for this disease each year, and this policy should be adopted by all nurserymen who grow peach stock. The curl usually appears in epiphytotic form, causing heavy losses one year while the next year the stock may be entirely free from it. One man with a hand sprayer can thoroughly cover twenty thousand stocks in a day. The annual cost of this operation can be compared in no way with the great insurance afforded against the disease in years when the curl is destructive.

LEAF-BLIGHT OF PEAR AND QUINCE

Leaf-blight of pear and quince, sometimes called fruit-spot or scald, has been known for many years in America as well as in Europe, where it was reported in France as early as 1815. It is known to occur in practically all countries where pears are grown, and also on various other hosts. The disease is prevalent particularly in Germany, Sweden, Italy, and France. In the United States it is most common in the pear-growing sections of the Appalachian region, and the disease is well known in practically all nursery districts.

Occurrence on different hosts

In the nursery the disease is usually found in abundance on budded quince stock and pear seedlings (Duggar, 1898). It is known to occur also on Cratægus and apple,[4] and according to Southworth (1889) it has been found on *Cotoneaster tomentosa* and *Mespilus germanicus*, two plants related to the quince and the pear. All the standard varieties of quince grown in New York State nurseries are susceptible to the disease. The same may be said of the pear varieties, but the Kieffer and the Angouleme are perhaps more resistant than the Seckel and the Wilder Early. The Flemish is only occasionally attacked.

An abundant infection on both the leaves and the twigs was observed in 1913 on two-years-old trees of *Cratægus oxyacantha*, variety Paul White Thorn. Adjoining these in the same block were trees of *Cratægus oxyacantha*, variety Double White Thorn, which were practically free from disease.

Symptoms

Leaves, petioles, leaf scales, twigs, and fruit may be attacked. The disease appears first on the leaves as small discolored areas on the upper surface, which become carmine-red in the center, with dull borders, and

(1889) Southworth, Miss E. A. Leaf-blight and cracking of the pear. U. S. Agr. Dept. Rept. 1888 : 357–364.

(1898) Duggar, B. M. Some important pear diseases. II. Leaf blight. New York (Cornell) Agr. Exp. Sta. Bul. 145 : 611-615.

[4] The foliage of two-years-old apple trees was observed by W. H. Burkholder and the writer to be affected with Entomosporium in the summer of 1912.

which finally penetrate to the lower surface. The color soon changes from red to dark brown, and a minute, slightly elevated, black area appears in the center (Fig. 87).

The individual spots are more or less circular in outline. If the spots are very numerous, the tissue between them may be involved and the spots may coalesce. When the trees are severely attacked the leaves turn yellow or brown, especially those of quince, and readily fall. Complete defoliation of nursery stock is very common when this disease is severe.

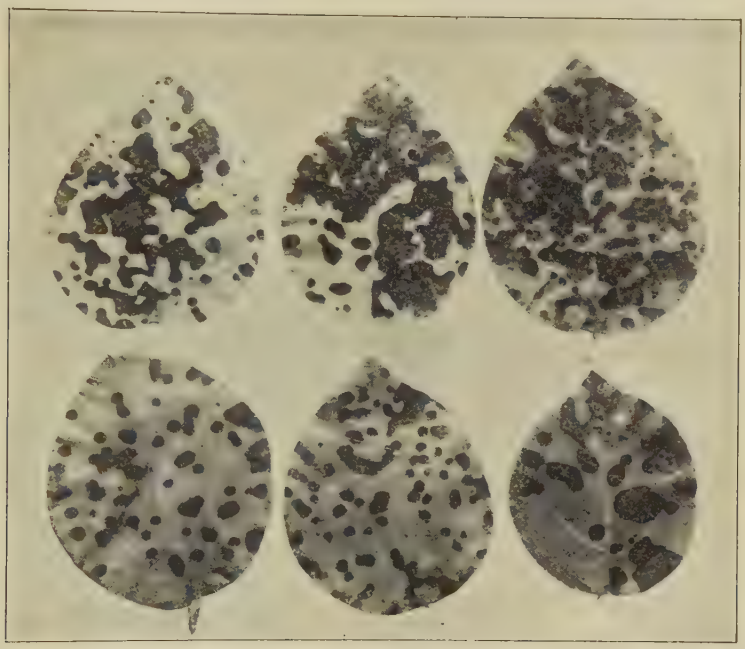


Fig. 87.— *Quince leaves affected with the leaf-blight disease, showing the dark red spots with black centers. The yellow discoloration also is apparent on some of the leaves*

Leaf-blight may be distinguished from the Septoria leaf-spot in that the spots are smaller, more colored when young, and somewhat more circular. The Septoria spots are apparent on the undersurface of the leaf. In the nursery, Septoria spot is generally found on budded pears, while leaf-blight is commoner on quinces and pear seedlings.

The development of the disease on the twigs is about the same as on the leaves. The spots are at first small and circular, but later they increase in length and become somewhat depressed, with a slight elevation in the center. The color finally changes to a brownish black. A twig

may be girdled by the disease, causing the death of the twig above the point of girdling.

Cause

The disease is caused by the fungous parasite *Fabræa maculata* Atk. The fungus is also occasionally referred to as *Stigmatea mespili* Sor., but the former appears to be the more logical name for this organism. The parasitic stage of this fungus is known as *Entomosporium maculatum* Lev.

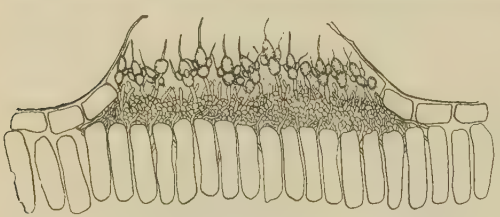


FIG. 88.— *Cross section of acervulus of fungus on quince leaf, showing the insectlike spores. The cuticle and the epidermal cells of the leaf have been pushed up and broken*

Life history

The small black specks previously mentioned, which develop in the center of the affected areas of the leaf, are the reproductive bodies (acervuli) of the fungus. Within the acervulus (Fig. 88) spores are developed, which on being discharged are carried by wind and rain to the foliage. Under favorable conditions, with the presence of moisture, the spores germinate (Fig. 89) and produce new infections. After three or four weeks acervuli develop in the new infections, and from these spores are discharged In this way the fungus is propagated throughout the summer.

Some of the spores may live over winter on the diseased twigs and produce new infections when growth starts in spring; but no doubt the greater proportion of infections in early spring is due to the sexual stage (perithecia) of the parasite. The perithecia develop on the fallen leaves, and the next spring discharge many spores which are carried by wind and rain to quince and pear foliage; the spores germinate with the presence of moisture, and produce the first infections of the season.

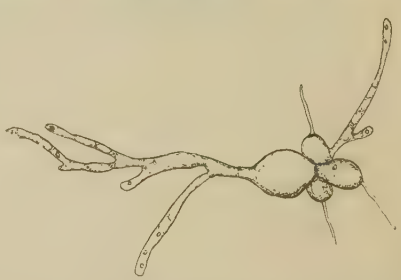


FIG. 89.— *An Entomosporium spore which has germinated. Germ tubes have developed from two cells of the spore. Highly magnified*

Cross inoculations

Cratægus on pear and quince.— Abundant leaf, petiole, and twig infection of *Entomosporium maculatum* was observed on June 13, 1913, on two-years-old trees of *Cratægus oxyacantha*, variety Paul White Thorn. Spores from acervuli on the leaves were placed in water. By means of an atomizer two pear seedlings and two

quince seedlings were sprayed with the suspension of spores. Two pear seedlings were sprayed with sterile water for checks. The seedlings were then placed in moist chambers for three days. Seven days later infections were apparent on all the inoculated seedlings; mature fruiting bodies developed on the inoculated leaves within twenty to twenty-five days after inoculation. The check trees remained healthy.

Pear on quince and Cratægus. — On June 23, 1913, two quince seedlings and two Cratægus shoots were inoculated, in the manner described above, with Entomosporium spores from diseased pear leaves. Two quince seedlings were sprayed with water free from spores as checks. Infections on both quince and Cratægus were found after ten days. Mature fruiting bodies developed after twenty-four days. The check trees remained healthy.

Quince on pear. — On June 28 Entomosporium spores from affected leaves from two-years-old budded quince trees were used for the inoculation of three pear seedlings. Inoculations were made as described above. Two pear seedlings were used as checks and were sprayed with water free from spores All the inoculated trees were placed in moist chambers for three days. Infections were apparent on the inoculated trees nine days later; mature acervuli developed in twenty to thirty days after inoculation. The check trees remained healthy.

From these cross-inoculation experiments it is to be concluded that there are no physiological differences in the fungus on the various hosts. The same organism will attack pear, quince, and Cratægus.

Control

Bordeaux mixture of any standard strength has been shown to be effective for the control of this disease. Galloway's (1889, 1894) and also Fairchild's (1893-4) experiments on this disease in the nursery proved spraying to be profitable. Sprayed pear seedlings held their foliage much better than did unsprayed trees, and were also somewhat larger.

Experiments by the writer on the control of this fungus in the nursery have shown both bordeaux mixture and lime-sulfur solution to be effective. Lime-sulfur solution 1–50 is satisfactory as a preventive. It has been the experience of the writer that, as a rule, the spraying of pear buds and quince seedlings for leaf-blight is not necessary in the nursery. For budded quince stock, the first spraying should be made soon after the first leaves are developed, when the young buds are from eight to twelve

(1889) Galloway, B. T. Experiments in the treatment of pear leaf-blight and the apple powdery mildew. U. S. Agr. Dept., Veg. Path. Sec. Circ. 8 : 1–11.

(1893–4) Fairchild, D. G. Experiments in preventing leaf diseases of nursery stock in western New York. Pear leaf-blight. Journ. myc. 7 : 241–247, 338–351.

(1894) Galloway, B. T. The effect of spraying with fungicides on the growth of nursery stock. U. S. Agr. Dept., Veg. Path. Div. Bul. 7 : 1–41.

inches in height. Subsequent sprayings should follow at intervals of from ten to fourteen days until about five applications have been made. For a rainy season it may be necessary to make one or two extra applications, it being essential to keep the new leaves covered with the fungicide.

The foliage of newly planted seedlings does not develop as early as stock that has remained in the ground over winter, and therefore the first spraying for leaf-blight on pear stocks can be delayed somewhat. It is advisable, however, to make the first application soon after the first leaves are developed. Four or five sprayings throughout the summer are sufficient to keep the disease in check. When extreme dry weather prevails throughout early summer and midsummer, the intervals between the first sprayings may be extended somewhat. If the applications are made at intervals of three weeks or less, a greater proportion of the foliage is protected at all times.

The addition of 3 pounds of iron sulfate to lime-sulfur solution 1–50 greatly increases the sticking qualities of the mixture on pear foliage.

SEPTORIA LEAF-SPOT OF THE PEAR

Leaf-spot of pear is common in all the nursery districts of New York State and is widely distributed throughout the United States in both orchards and nurseries. It is known to occur in Europe also.

The disease is confined to the foliage, and in the nursery the budded stock is the most susceptible. Duggar (1909) observed that, while seedling pear stock in a nursery may show leaf-blight to a considerable extent, adjacent plats of budded plants may be seriously injured by leaf-spot. The budded stock of the second year usually suffers seriously. Sorauer (1908) states that the disease is occasionally found on apples.

When leaf-spot is abundant, considerable premature defoliation results and the growth of the stock is checked. As a rule, however, the disease is not so destructive as the pear leaf-blight so commonly found on pear seedlings.

Certain varieties of pears are more susceptible to the disease than others (Duggar, 1898). In the nurseries of New York State, observations throughout several seasons show the following varietal differences in resistance to the leaf-spot: most severely attacked, Sheldon, Seckel, Bartlett, Wilder Early; considerably injured, Worden, Anjou, Howell, Vermont Beauty, Flemish, Koonce, Clapp Favorite, Clairgeau; most resistant, Kieffer, Garber, Mount Vernon, Lawrence, Angouleme.

(1898) Duggar, B. M. Some important pear diseases. I. Leaf spot. New York (Cornell) Agr. Exp. Sta. Bul. 145 : 597–611.
(1908) Sorauer, Paul. Septoria piricola. Handbuch der Pflanzenkrankheiten 2 : 408.
(1909) Duggar, B. M. Fungous disease of plants, p. 358–360.

Symptoms

Only the leaves are affected. The lesions appear first on the upper surface as discolored spots, which are rather characteristic and make the disease easily recognized. Usually the spots are not abundant on a leaf unless the disease is exceptionally common; under this condition some of the lesions may coalesce, involving the healthy tissue between. The affected area is somewhat angular in shape; the outer part of the spot is brown or black in color, while the well-differentiated center is light

FIG. 90.— *Pear leaves affected with the Septoria leaf-spot disease. Some of the spots show the dark specks (pycnidia) in the center of the white areas*

gray, with six to twelve minute black specks which are very apparent in old leaves. The spots measure, on an average, one and one-half to two millimeters, and the grayish center is somewhat transparent (Fig. 90).

The leaf-spot disease can be distinguished readily from the leaf-blight by the larger angular lesions, which show through more distinctly on the undersurface. The gray center of the leaf-spot lesion is also characteristic. The leaf-blight areas are more highly colored when young, and are circular, not angular, in outline.

Cause

The disease is caused by the fungus *Mycosphærella sentina* (Fckl.) Schröter. The conidial stage, *Septoria piricola* Desm., is the parasitic form of the fungus, and it is this stage that attacks the living pear leaves throughout the growing season. Klebahn (1908) showed that *Mycosphærella sentina* on old wintered-over pear leaves is the sexual stage of *Septoria piricola*.

Life history

The minute black specks, previously mentioned as occurring in the center of the spots on the leaf, are the pycnidial fruiting bodies. Spores are pushed out of the opening at the tip of the pycnidium (Fig. 91) in the form of a dark-colored, tendril-like mass. Carried by the wind or by a spattering drop of rain, a spore falls on a pear leaf and, if sufficient moisture is present, germinates. The germ tube penetrates the leaf tissue and develops a mycelium, and the new infection is established. In this lesion new pycnidia are produced which bear spores, and thus the pathogen is spread throughout the summer.

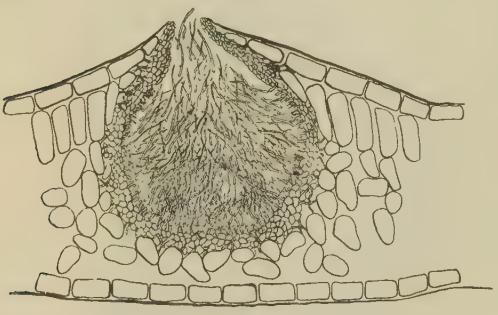


FIG. 91.— *Cross section of pear leaf, showing a pycnidium of the Septoria fungus and the needlelike spores, some of which are escaping through the opening in the top of the pycnidium*

The fungus lives over winter on the fallen pear leaves in the form of a specialized reproductive body known as a perithecium. In spring ascospores are discharged from the perithecia, and, falling on the newly developed foliage, germinate when moisture is supplied. In the lesions of these first infections pycnidia are produced, which are the means of further dissemination of the fungus.

Control

The leaf-spot of pear can be controlled by spraying with bordeaux mixture or with lime-sulfur solution 1–50. It is advisable to spray the two-years-old budded pear trees soon after the first new leaves are developed in spring. This spraying should be followed by another application two to three weeks later. If the season is extremely wet and the disease very common, one or two subsequent sprayings will prove beneficial.

(1908) Klebahn, H. Untersuchungen über einige fungi imperfecti und die zugehörigen ascomycetenformen. V. Septoria piricola Desm. Zeitschr. pflanzenkr. **18** : 5–17.

It has been the experience of the writer that in an average year it is usually not profitable to spray one-year-old budded pear stock for this disease. During the several years that the disease has been under observation in the nurseries of New York State, the writer has never noticed leaf-spot causing any heavy defoliation of one-year-old trees.

BLACK SPOT OF ROSES

The disease known as black spot, leaf-blotch, or leaf-spot is one of the most destructive diseases occurring on roses. The disease has been known for nearly a century, and is found in practically all the countries of Europe as well as being widely distributed in the United States (Scribner, 1888). In nurseries the plants that are severely affected become defoliated during the summer, in many cases causing the leaf buds, which should remain dormant until the following year, to open late in the season. The defoliation checks the growth and also prevents proper maturation of the wood, and when dug the stock is not likely to keep so well in storage. In the following spring, when these bushes are put on the market, they go out as weakened plants so that they blossom poorly or not at all. Stock that makes a good growth and is productive the first year it is set out is most desired by the nurserymen's trade.

The disease is also destructive in the greenhouse, especially where cuttings are propagated and later planted in the nursery row. The small plants in pots are often badly injured, a large proportion of the foliage being affected. When these potted roses are transplanted to the field, the weakened condition of the foliage retards the development of the plants and in some cases they die, especially if the season is dry.

Varietal susceptibility

Practically all varieties of roses are affected, both in the nursery row and in the greenhouse. The wild species, *Rosa humilis*, has been reported by Halsted (1893) as being attacked when growing in the garden near diseased roses. Certain forms are known to be resistant. Wolf (1913) makes the following statement:

"*Rosa gallica*, *R. centrifolia*, *R. rubiginosa*, and *R. indica* exhibit a marked degree of resistance. Some forms are entirely free from attack. Briosi and Cavara note that only four varieties, *Rosa hybrida*, varieties Bell Angevine, Triomphe d'Alencon, Abel Grant, and *Rosa borboniaria*, variety Triomphe d'Anger, of the six hundred growing in the botanical gardens at Pavia are free from attack. Laubert and Schwartz point out

(1888) Scribner, F. L. Black-spot on rose leaves. U. S. Agr. Dept. Rept. 1887 : 366–368.
(1893) Halsted, B. D. Fungous troubles of roses. New Jersey Agr. Exp. Sta. Rept. 13 : 280–281.
(1913) Wolf, F. A. Black spot of roses. Alabama Agr. Exp. Sta. Bul. 172 : 113–119.

the fact that the bushy sorts are more susceptible than the climbing varieties, and also that those with thin leaves are most liable to attack."

Symptoms

The symptoms of the disease are the black, sootlike blotches on the upper surface of the leaves (Fig. 92). The more or less circular spots are at first small, but they increase in size to a half inch in diameter. Often a number of the spots coalesce, and in time the leaf may be nearly covered with the large dark areas. A very marked character is the fringed border of the spots. The affected areas of the leaf turn yellow, and this yellowing may involve the entire leaf before it falls to the ground.

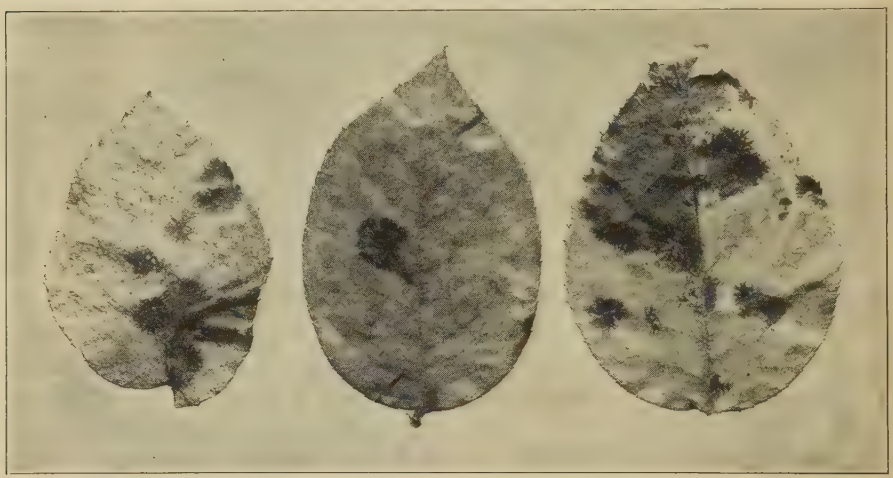


FIG. 92.— *Rose leaves showing the black-spot disease*

Cause

The cause of the disease, as determined by Wolf (1912), is the fungus *Diplocarpon rosæ* Wolf. The conidial, or vegetative, stage, which is the active parasite on the living foliage, is known as *Actinonema rosæ* (Lib.) Fr.

Life history

The disease usually first appears in the nursery in early summer, about the time when other leaf-spots are developing. In the affected areas on the leaf, fruiting bodies (acervuli) are developed, and these discharge spores which are carried by wind and rain to healthy rose leaves. In the presence of moisture the spores that fall on the leaves germinate and

(1912) Wolf, F. A. The perfect stage of Actinonema rosae. Bot. gaz. 54 : 218–234.

produce new infections. It is in this manner that the fungus is spread throughout the summer.

The fungus lives over winter in the fallen leaves. The reproductive fruiting bodies which are developed in these old leaves mature in spring, and ascospores are discharged which are carried by wind and rain to the new foliage, where the first infections of the season occur. In the presence of moisture, these ascospores germinate by a germ tube, and within eighteen days after infection the acervuli, with mature spores, have developed.

Control

Bordeaux mixture may be used for the control of this disease. No experimental data are at hand as to the efficiency of lime-sulfur solution as a preventive. Lime-sulfur solution 1–50 has been used for the control of rose mildew, with no resulting injury to the plants. No doubt this solution would be efficient also in checking the black spot disease if applied at the proper time.

Bordeaux, and also lime-sulfur, are objectionable in many cases because of the spray mixtures coating the foliage and the blossoms. The presence of the fungicide on the bushes, however, is of no consideration to nurserymen, and for that reason bordeaux mixture may be recommended for use against this disease.

The first application should be made in early summer, soon after the first new leaves are developed. In rainy seasons the disease is naturally more severe and the sprayings need to be made more frequently. However, as a general recommendation, five or six applications throughout the summer should be sufficient to keep the fungus in check.

MILDEW OF ROSE AND PEACH

Mildew is found on both the peach and the rose, but it is commoner on the latter. The disease is more destructive on peach nursery stock than on orchard trees, according to Whipple (1906); however, in the nursery it is usually prevalent only when there is an excessive amount of moisture and conditions are favorable for the disease. It has been the experience of the writer that, as a rule, peach mildew is not of sufficient economic importance to demand much attention in the nurseries of New York State.

Rose mildew is of great significance in the nurseries of the State and is in many cases very destructive. This is especially true of the young plants growing on their own roots. If weather conditions are favorable to the disease, potted roses may often be affected seriously when they are transplanted to the field from the greenhouse in spring. Certain varieties

(1906) Whipple, O. B. Peach mildew. Colorado Agr. Exp. Sta. Bul. 107 : 1–7.

of potted roses may be injured so severely by the mildew that they make but little growth throughout the summer. In many cases stock checked in this way during the vital period of its development fails to make sufficient growth in the second summer in the field to be dug that season. This condition is more prevalent when the plants are affected by mildew and other leaf diseases again in the second year. Budded roses also are susceptible to mildew, and very often their growth is checked by the disease.

Some growers are of the opinion that severely mildewed rose stock does not keep well in storage. It is claimed that the tips of the affected shoots tend to rot and decay when subjected to the moist condition of the cellar. No experimental data are at hand to substantiate this opinion, but under ordinary conditions it is probable that the mildew disease which has affected the bushes in the summer has little or no direct influence on stock while it remains in the cellar. The mildew dies in the autumn and does not continue to spread throughout the winter. It is known that mildew kills back the tips of the shoots, but such injuries, in the writer's opinion, would be comparable to any mechanical injury that might kill the tip of a shoot. This disease is often very destructive to rose cuttings and also to stock plants in the greenhouse, according to Schultheis (1899).

Varietal susceptibility

Certain varieties of roses show more resistance to mildew than do others. The rambler varieties and the moss roses are usually the most severely affected. A serious outbreak of rose mildew occurred in one of the large nurseries in the season of 1913. There were about forty-five varieties of roses growing in one block under the same conditions, and thus a good opportunity was afforded for observations on the resistance of these varieties to mildew.

The varieties most severely affected were: Flower of Fairfield, Crimson Rambler, Anna Mueller, Margaret Dickson, Salet Moss, Blanche Roberts, and Frau Karl Druschki. The varieties showing practically no mildew when the last observations were made, on August 10, 1913, were: Dorothy Perkins, Orleans, Mrs. Taft, Princess Adelaide, Caroline Mariner, and American Beauty. All the following varieties were at least slightly affected by the disease: Victor Verdier, Mary Washington, General Washington, Madame Caroline Testout, Baby Rambler, Wichuriana, Fisher Holmes, Gruss an Teplitz, Earl of Dufferin, Lady Gay, Queen Prairie, Madame Margotten, Madame Plantier, Francois Levet, Catherine Zeinner, William Lobb, Duke of Edinburgh, Madame

(1899) Schultheis, A. Mehltau an rosen. Zeitschr. pflanzenkr. 9 : 128.

Gab. Luizit, Empress of China, John Hopper, Magna Charta, Clemence Raoux, Clio, Marshall P. Wilder, John Keynes, C. F. Meyers, Devoniensis.

Symptoms

The leaves, especially the young ones, the blossom buds, and the young shoots of roses are affected by mildew. The disease occurs on

PHOTOGRAPH BY B. M. DUGGAR

FIG. 93.— *Peach shoots severely mildewed*

the leaves, the twigs (Fig. 93), and also the fruit of the peach. The symptoms on the two host plants are practically the same.

On the leaves of the rose the disease may occur on either the under or the upper surface, or on both. It appears as white, irregular blotches. The leaves become arched or curled and dried out, usually curling upward

along the midrib. When the disease is severe the younger leaves at the end of the shoots often fall prematurely.

The dense, white blotches on the twigs caused by the mildew are similar to those on the leaves. The bark becomes dead in appearance on severely affected shoots, and shrivels, causing an arching or a curving of the shoots at the tip. Only the current year's growth is affected. Often mildew covers the foliage at the tips of the shoots so completely that certain varieties of rosebushes appear at a distance to be almost white. This is often particularly noticeable in a block of roses containing numerous varieties. Such roses as the Crimson Rambler may have the white appearance due to the mildew, while in adjoining rows the foliage of another variety will be green and free from mildew.

On some varieties the mildew is commonly first observed on the blossom buds, where it appears as thick, white, irregular blotches.

Cause

The fungus *Sphærotheca pannosa* (Wallr.) Lév. is the cause of the mildew on peach and rose stock. The conidial form is *Oidium leucoconium* Desm. This fungus is similar to the organism causing mildew on apple (Fig. 70, page 183).

Life history

Soon after the white blotches of mildew appear on the host plant, profuse numbers of conidia are produced (Fig. 94) which are scattered to the new foliage by wind and rains. These conidia propagate the fungus throughout the season. After midsummer the special fruiting bodies known as perithecia may also be produced, which are resistant to cold and serve to bridge the fungus over winter. In spring or early summer, ascospores are discharged from the perithecial fruiting body, and, falling on the new foliage, produce infections which are apparent some days later as small, white areas, the beginning of the thick, white blotches of mildew.

Control

Most copper sprays have not proved effective in controlling this disease, but compounds containing sulfur have been effective. Dusting with flowers of sulfur, spraying with lime-sulfur solution, and spraying with lime-sulfur to which iron sulfate has been added, have been tried in the nursery with a considerable degree of success.

For a normal year perhaps the simplest means of control for this disease is dusting with flowers of sulfur. The sulfur can be easily and rapidly applied with a dusting machine which blows out the sulfur in a fine dust. It is often desirable to dust as early as possible in the morning,

while the dew is still on the foliage. If dry, hot weather follows the dusting, the efficiency of the sulfur against the mildew appears to be increased. Rain washes off a certain amount of the sulfur dust, but a considerable amount remains unless there is a prolonged period of wet weather. With frequent heavy rains when the mildew is well established and abundant, the dustings need be made at shorter intervals in order to keep the new growth protected.

Lime-sulfur solution 1–50 is effective in checking mildew, but better results have been obtained by the use of lime-sulfur solution 1–50 with

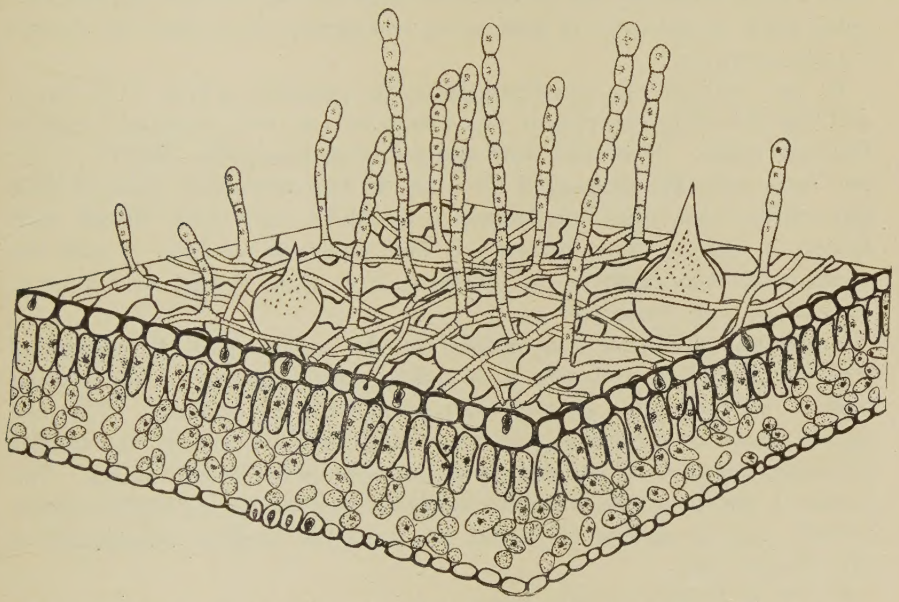


FIG. 94.— *Diagrammatic section of a piece of leaf tissue, showing the mildew fungus on the surface, with conidiophores and chains of spores reaching into the air and haustoria extending into the epidermal cells of the leaf. Magnification 150. After F. M. Blodgett*

the addition of 3 pounds of iron sulfate to 50 gallons of the mixture. The precipitated sulfur resulting from the addition of the iron sulfate appears to have better covering qualities and also sticks better.

The first treatment for mildew should be made as soon as the disease appears and before it has become thoroughly established. The abundance or prevalence of the disease should determine the time interval and the number of applications for effective control. In some seasons one or two applications are sufficient, while in other seasons it is profitable to increase the number of applications to five or six, making some of these

at intervals of nine days or oftener. Under such conditions it is often preferable to dust rather than to spray, owing to the ease and rapidity with which the former may be done. Foliage sprayed with the precipitated sulfur is, as a rule, protected more effectively for a greater length of time; but often there is need of frequent sprayings in order to protect the young developing shoots and leaves where the attacks of the mildew are most severe.

Owing to the fact that spraying involves considerable time and labor, one or two sprayings with the precipitated sulfur, in order to keep the older foliage protected, can be combined with dusting; the dust applications being made at intervals of from seven to fourteen days when the disease is most prevalent.

In 1911 mildew was very abundant in the nurseries of New York State, and the following experiment was conducted on two-years-old Crimson Rambler roses: Two rows were sprayed with lime-sulfur solution 1–50; two rows were left unsprayed for a check; two rows were sprayed with lime-sulfur 1–50, plus iron sulfate 3–50; three rows were dusted with flowers of sulfur. The mildew was first observed on July 12 and the applications were made on the following dates: July 18 and 28, August 4, 11, and 19, and September 1.

A marked difference was noticed in the treated and the untreated rows by August 4, and very little mildew was apparent on the treated bushes, which made a good growth throughout the summer. The tips of the shoots on the check rows were badly affected, and by the middle of August many of these diseased shoots were curled and dried up. The bushes in the check rows were also somewhat smaller, having made a slower growth; and in general these did not have the healthy appearance of the treated rows.

Submitted for publication February 9, 1915.